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Contents

Original Articles

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From the Editors-in-Chief

ARTIFICIAL INTELLIGENCE FOR SCIENTIFIC RESEARCH – LARGE LANGUAGE MODELS IN MANUSCRIPT PREPARATION

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Abstract: *Artificial intelligence has the potential to revolutionize scientific work. At the same time, the availability of large language models, coupled with high publication pressure, often distorts the way AI tools are used. This study highlights not only the potential of selected contemporary tools, but also the traps and risks that come with using AI tools in the preparation of scientific papers. Wise use of AI techniques can improve the efficiency of work, but an unprofessional approach results in journal clogging and devaluation of the traditional form of sharing scientific achievements.*

Keywords: *manuscript preparation, artificial intelligence, large language models.*

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INTRODUCTION

The development of generative artificial intelligence tools, especially publicly available large language models concealed in the form of conversational agents or chatbots, such as ChatGPT, is strongly revolutionizing the traditional system of scientific work. Increasingly large learning datasets and increasing number of parameters make it possible to perceptibly experience the growth of knowledge accumulated in large language models, but is there a proportional increase in awareness among users of how to practically and ethically use the achievements of modern technology?

It is important to realize that knowledge gain does not go hand in hand with knowledge structuring. Artificial intelligence models have historically been taught to return a corresponding output for a given vector of input features. Popular tools thus provide data on an action-reaction basis. Increasingly generative language models with broad knowledge are thus able to provide a broad set of general information that is able to satisfy those with little knowledge in a given area, but does not answer the concerns of inquisitive scientists. But aren't inquisitive scientists able to take advantage of modern technological advances?

The key to answering the above questions is probably inquisitiveness and reliability, as well as awareness of the limitations of the technology used. In the background of the development of the models themselves, quite a lot of attention is focused on the so-called prompt engineering, the idea of which is to conduct a dialogue with a language model in such a way that through inquisitiveness and the appropriate selection of phrases (prompts) the relevant knowledge is extracted from the model. A systemic offshoot of this process is so-called fine tuning, whose task is to automatically refine the context of questions and the expected style of answers. In the context of the latest large language models, one can hear about the so-called reflective thinking (“slow thinking”) of chatbots, along the lines of human pondering, which, according to the creators' declarations, will make it possible to obtain a more plausible-looking answer or solution through self-reflection and self-correction of obvious imperfections.

Whether the ever-expanding language models will be smarter or just wiser remains to be seen, but it is already possible to explore their potential today. Among the works suggesting the use of chatbots for the preparation of scientific manuscripts, one can find such issues as literature review, data analysis, hypothesis formation, writing or proofreading of scientific texts. But can the tools be trusted in the scopes in question? Do they offer real support, or are they perhaps just wishful futurology that is not supported by existing research?

CRITICAL ANALYSIS OF LLMS’ USAGE

Scientific publications are one of the primary forms of knowledge sharing and dissemination of scientific achievements in research communities around the world. However, the dependence of scientific policies, including science funding, on scientometric indicators has substimulated an unnatural pressure to produce more and more momentous publications. Aside from the research itself, which is beyond the scope of this study, preparing a scientific text is undeniably a demanding and time-consuming process. The advent of AI tools to support the process of preparing scientific texts has strongly increased

the volume of articles being written and has clogged up the editorial offices of journals that are unable to process the supply of papers. To make matters worse, the quality of submitted manuscripts, often unethically supported by modern AI tools, raises the question of what to pay attention to when editing a scientific text. Each year more than 15 million hours are spent reviewing articles that are rejected (AJE, 2018).

The advent of specialized tools such as Consensus[1], Semantic Scholar[2] seemingly makes it easier to find works related to the research topic. It is unfortunate that many authors stop at the descriptions generated by the tools, rather than studying the sources these tools suggest. Although any selection of sources is characterized by bias, the most valuable thing in a review is critical analysis, highlighting the inadequacies and shortcomings of earlier studies, rather than just unreflectively citing what is found in them. Thus, most automated literature reviews do not provide adequate background to the authors' contributions.

Peer review tools for scientific articles are also emerging, which can be thought of as a multi-criteria pre-evaluation of one's work (Kousha et al. 2024), but the reviewers themselves, if they limit their intellectual input to repeating the system's recommendations, will consciously give up the expert advantage provided by human brains and experience.

In the context of editing text, the notion of research productivity sometimes arises, which can be associated with the overproduction of articles. Research (Noy et al., 2023) shows that professional scientists facing the need to complete a motivating writing task may be more satisfied with their work when they can support themselves with generative tools. Another study (Campero et al., 2022) shows that inexperienced people supported by generative AI tools can write computer programs more effectively than programmers. Furthermore, it has been shown that the synergy of a human with an AI tool, is possible when the context of the activities is well defined. Either the scientist knows exactly what he or she wants to write, and only uses the tools as a word generator, styling the utterance - formulating sentences, or then because the formal requirements for the result of the work - the computer program code - are known.

The use of AI tools is different in the context of text translation or language correction. In this field, the proficiency of AI tools is unquestionable, but often it is necessary to refine the vocabulary to the nomenclature adopted in the field of research. Similarly, the unquestioned competence of tools appears in the field of data processing. After all, this is what humans develop computers for. However, it is worth noting that the automation of data processing and analysis deprives authors of vigilance regarding the correctness of the data themselves and the analysis performed. Paradoxically, the larger the data set, the more justified it seems to be to use tools to analyze it, and the less we can control the correctness of the analysis itself.

[1] https://consensus.app/
[2] https://www.semanticscholar.org/

CONCLUSIONS

Summarizing the development of large language models and the potential for their use in editing scientific texts, it can be assumed that they will be incorporated more and more often in various stages of editing, editing or proofreading scientific texts. Convenience of functioning and the desire to make one's work easier, will build an increasingly tight context, describing the multi-criteria conditions of scientific works. This, in turn, will lead to the dehumanization of the creative process of writing scientific documents, and the consequences of this change are difficult to predict.

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DESIGNING A GOOD STORY FOR BETTER POLICIES: ENTREPRENEURSHIP AT THE CROSSROADS OF AI-POWERED VISUAL STORYTELLING AND SENSEMAKING

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Abstract: *Sensemaking and AI image generators can contribute as visual storytelling tools to a better comprehension of the life-worlds of entrepreneurs in policymaking. There is doubt about whether policymakers productively understand entrepreneurial realities for the sake of implementing decisions that help startups. Using entrepreneurial journeys of 18 startups in six countries, weak-signal triads and image prompts were derived from shared stories in order to visualize entrepreneurial realities. The advantage of visual storytelling materializes in the cognitive ease that narrative schemas yield. Results indicate that AI generated visuals, e.g. storyboards, depict compelling realities regarding story elements such as character and setting clearly, yet they hardly illustrate the dynamics thereof (e.g. conflict resolution), while triads help understand entrepreneurial priorities. The project showcases the potential of tech-driven visualization, suggesting that visual arts can help the public understand untold stories that drive, among others, entrepreneurial solutions, provided that the dynamics be presented clearly.*

Keywords: *AI-imagery, storytelling, entrepreneurship, public policy, story design, visual storytelling.*

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INTRODUCTION

"...in an information-rich world, the wealth
of information means a dearth of something else:
a scarcity of whatever it is that information consumes (…)
Hence a wealth of information creates a poverty of attention
and a need to allocate that attention efficiently."
Herbert Simon (1971, p.40-41)

As generative Artificial Intelligence (AI) tools for static and animated visuals have become increasingly popular and accessible in recent years (Hu, Cheng, Gan, Liu Gao and Neubig, 2020; Nield, 2024), harnessing their benefits can include understanding the life worlds of actors that generate public value in society, for example, entrepreneurs.

This finds relevance, i.a. in the design of better policies, which evolve in a context of limited resources, scarce attention, and bounded rationality (Simon, 1971, 1990). The challenge is, however, how this process of understanding can come about when using available toolsets and recognizing that entrepreneurial journeys are not necessarily understood by policymakers (Bosma & Levie, 2020; Haden, 2014; Instituto Superior para el Desarrollo del Internet - ISDI, 2015).

Storytelling and entrepreneurship go back a long way; one may even posit that there is no entrepreneurship without a story. As Fisher (1985, p. 75) writes, referring to the narrative paradigm, humans are storytellers *per se*. For Srivastava, Oberoi and Gupta (2023), who concentrate on compelling storytelling for entrepreneurs to gain competitive advantage, storytelling appears as a crucial component of any entrepreneurial journey, even if every story must be tailored to its specific context and goals. Policy, including decisions that benefit startups, can be enriched using storytelling as a means to 're-frame" situations towards change (Lowndes, 2016, p. 120), also benefitting from clearer inputs that depict the situation of the entrepreneur for policymakers.

Visual storytelling, also known as narrative visualization (Mayr & Windhager, 2018) can contribute to making sense of how entrepreneurs operate and effectuate amid uncertainty, albeit in a way that guarantees a systematized story capture that delivers clear and comparable patterns of information. This implies that story elements, (e.g. characters, setting and conflict) are visualized and help "tell the story". Thus, visual storytelling helps understand journeys by making it cognitively easier to appraise content. If communicated clearly and consistently, visuals that help disseminate knowledge or ease a decision maker's understanding, illustrating "lived experiences" (Drew, Duncan & Sawyer., 2010, p. 1677).

In this light, this paper addresses whether and how visual storytelling can incorporate available toolsets to better portray entrepreneurial journeys in a policy setting using two examples. On the one hand, SenseMaker, a human sensemaking tool, was used to collect entrepreneurial stories and interpret signals based on available patterns. The stories stem from entrepreneurs in six countries during the COVID-19 pandemic. On the other hand, the extracted bodies of stories were used to create storyboards using Midjourney, a generative AI-software.

This paper is structured as follows. The first section provides a literature review on visual storytelling, sensemaking and entrepreneurial journeys, followed by a second section that

discusses a theoretical approach on narrative visualization. The third section introduces the methodological approach, which is built on the use of the two tools and an overview of the results and a sample of the visuals, while the fourth section addresses a general discussion on the matter and a set of policy recommendations.

LITERATURE REVIEW

The recent body of literature linking storytelling and entrepreneurship involves topics such as startup funding and stories (Anglin, Reid & Short, 2023; Manning & Bejarano, 2017; Martens, Jennings & Jennings, 2007), the communication of unique differential values of entrepreneurial ventures (Taeuscher. Bounchken & Pesch, 2021), the role of 'place" in entrepreneurial storytelling (Kimmitt, Kibler, Schildt & Oinas, 2023), the role of storytelling in entrepreneurial intention (Liu , Ma & Li, 2019), storytelling as a skill for entrepreneurs (Srivastava et al., 2023), among others.

Visual storytelling has established itself in the scientific literature covering different domains. Botsis, Fairman, Moran and Anagnoustou (2020) apply it to enhance knowledge dissemination in medicine, while Drew et al. (2010) explore the use of photovoice and photo-elicitation as visual storytelling techniques in qualitative health research. From a theoretical perspective, Akleman, Franchi, Kaleci, Mandell, Yamauchi and Akleman (2015) depart from narratological analysis and propose a framework that helps develop techniques of visual storytelling. An example of the recent use of visual storytelling and technology is provided by Hu et al. (2020), who explore elements that 'make a good story' in the context of artificial intelligence and the coherent description of image streams. Also in the same direction, Zhang, Yin, Geng, Zhou, Sun and Tang (2020) apply different visualization techniques to facilitate the communication of spatial-temporal narratives in ancient poetry, albeit for the sake of improving education techniques.

Beyond the grey literature that involves visual storytelling, business, and entrepreneurship (e.g. Kleine Wieskamp, 2019), there are scant accounts of the link between the two topics and the potential of their interaction in scientific literature. On the one end, Rivo-López, Lampón, Villanueva-Villar and Míguez-Alvarez (2022) explore the impact of introducing visual narrative formats in entrepreneurship training for women. They find positive effects of using visual narrative to develop better entrepreneurial concepts, identify opportunities and even encourage innovation. On the other, Gates-Stuart (2019) discusses, i.a. the link between digital entrepreneurship and its use of visual narratives of storytelling in different research approaches. However, to the best of our knowledge, the use of visual storytelling depicting the lifeworlds of entrepreneurs, let alone economic actors, as a tool for better policy decisions is practically inexistent in the scientific literature. This includes the lack of examples or case studies where policy making could better absorb entrepreneurial input in order to provide better solutions.

One must not forget, however, as Davidson (2017) notes, that the grey literature[1] also offers a vast amount of input with regards to storytelling and academic domains, for example, policymaking. This means that the gap we mention does not cover the vast amount of resources

[1] Davidson (2017, p.2) understands the grey literature as "literature produced in government, academia and industry that is not controlled by commercial publishers".

available with regards to applying storytelling techniques for entrepreneurial purposes. A simple Google search query using "storytelling for startups" yielded at least 8 million results in early 2024. This means that there is a vast resource pool for entrepreneurs who wish to use storytelling as a resource for their business, yet the gap we address relates to how storytelling can be used to better visualize entrepreneurial issues in the framework of policymaking.

THEORETICAL APPROACH

Stories are, i.a., dynamic artifacts that recreate imagined or lived experiences; they help us process complex information (Davidson, 2017) and reflect a way of organizing human experience (Mayr & Windhager, 2018). This view of stories can be grasped from the seminal work of Bartlett (1995 [1932), who proposed the concept of schema in psychology. For him, a schema goes beyond a mere pattern of information; it is an "active organisation of past reactions, or of past experiences, which must always be supposed to be operating in any well-adapted organic response" (p.201). In other words, a schema is an abstraction that we derive from experience, which then contributes to processing new information. Consider story characters as an example of how new information can be processed. Recognizing, for example, the hero and the villain is a possibility that regards how we categorize information in stories (Davidson, 2017).

Mandler (1982) linked the concept of schema with the capability of generalizing and abstracting, which humans build when interacting with the environment (p.16). When considering story 'elements', e.g. characters, plot, resolution or moral (Davidson, 2017) as abstractive structural input within imagined scenarios, the story becomes a narrative schema, one governed by a set of rules similar to those of language (Stein & Kissel, 2010, p. 567). In narrative discourse, the narrative schema is understood as a "principle for meaning construction", i.e. a "major cognitive schema (…) in terms of which partial significations can be combined into a coherent whole" (Bundgaard, 2007, p. 248).

Stories can also be seen as a possible set of mental simulations where the daily life of the audience is briefly put aside (Blythe, 2017; Oatley & Johnson-Laird, 2014). When it comes to visual storytelling, this 'simulation' is complemented with further symbolic details that ease and even guide the audience, i.e. the use of graphics, animations, 3d models, colors, and other visual elements. Color, for example, is known to help the audience anticipate particular actions (Bellantoni, 2013), thereby simulating one or several experiences. Public art, (e.g. murals), appears as a tool and storytelling device for dialogue and identity construction, leading to a complex temporal dimension or a juxtaposition of periods (Hamilton, 2016, p. 11). In this sense, visual arts help tell transformative stories, i.e. they symbolize temporal change within a particular social context (Van Dahm, 2017).

Among the three steps that Botsis et al. (2020) lay out regarding a powerful visual story for knowledge dissemination, i.e. defining the target, checking for its understanding of the topic, and story design, the latter signals that the visual storyteller has the potential to design the 'simulation' and therefore the experience of abstracting from reality or simply recreating it in different ways. Following Zhang et al. (2021), visual storytelling helps explicitly present both latent and abstractive elements of stories. With this in mind, we suggest grasping visual

storytelling as a simulated environment of abstraction with potential deep meanings, i.e. a framework of communication in which schemata operate.

As Botsis et al. (2020), argue, science and design can come together in visual storytelling combining functionality and decoration for a higher purpose such as communicating scientific knowledge. Yet knowledge dissemination is one of many potential goals. Consider the role of simply communicated information for the purpose of better policymaking towards entrepreneurship[2]. This implies that story design may be essential for effectively communicating information to decision makers.

Figure 1 illustrates the issue of having a bulk of information, i.e. a collection of stories that may have difficulties reaching decision makers. The use of (visual) storytelling thus serves as a cognitive filter that organizes experience (Mayr & Windhager, 2018) and can thus help inform decisions. In other words, storytelling can operate as a *cognitive filter* which, if used for the sake of better policies, may benefit entrepreneurs through well targeted policies. This, however, requires agency on the side of policymakers.

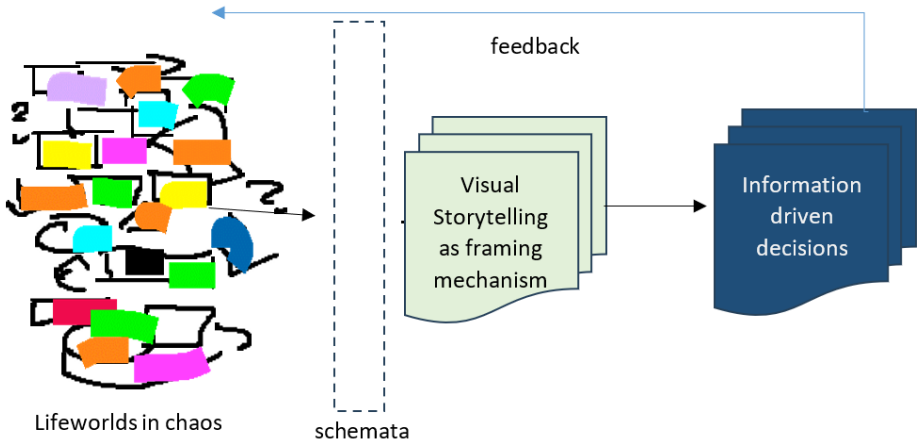

Figure 1. *From chaos to visual stories and informed decisions* . Visual storytelling contributes to organizing the bulk of information available. The role of narrative schemas is fundamental, as they operate as filters that make activate lived experiences on an audience. If this audience is to be a set of policy makers who require input for decisions that benefit startups, informed decisions can be made with a well-organized processing of information. The latter occurs under the narrative schema that includes story elements such as character, setting and conflict.

While there are patterns and trends in entrepreneurship that can help guide policymakers and development units to cultivate an ecosystem of support, the nature of entrepreneurship is about seeking and creating circumstances under which entrepreneurial outcomes – essentially in the form of new products, services or business models – can be introduced to markets (Venkataraman & Sarasvathy, 2001). Entrepreneurship, therefore, is marked by the management of uncertainty. Recent literature has linked the importance of on-going sensemaking to entrepreneurial activity (Cornelissen & Clarke, 2010; Hong, Zhao & Snell,

[2] For a discussion on the convenience of different types of small business-related policies, cf. Shane (2009) and Arshed, Carter and Mason (2014).

2022; Kimmitt & Muñoz, 2018; Niemi, Stenholm, Hakala & Kantola, 2022). As faced with a need to consistently interpret and create the market, entrepreneurs must make sense of, start connecting the dots and simultaneously react to a particular situation as it unfolds. Niemi et al. (2022) refer to this as entrepreneur's need for "immanent sensemaking", which they define as a routinized way of making sense of how to proceed in novel situations.

Sensemaking can be thought of as the way in which people make sense of the world and give meaning to life, i.a. through the construction of narratives (Fisher, 1985). People make sense of uncertain or unfamiliar stimuli through reframing and reconciling the new patterns and stimuli with a coherent story they can use to make sense of the situation. Narrated events and how one makes sense of them, therefore, are particularly useful for how entrepreneurs are managing the uncertainty linked to their projects. Yet not only is the entrepreneur relevant while making sense of the situation; the policymaker, if concerned with improving the context for better entrepreneurial outcomes, is also confronted with reading the situation of the entrepreneur and making sense of it productively.

METHODOLOGY & VISUALIZATION RESULTS

We approach entrepreneurial sensemaking through a period of extreme uncertainty, novelty and disruption brought upon by the COVID-19 pandemic, which started at the beginning of 2020. Building on entrepreneurs' sense of their businesses, this body of stories provided us with the basis to explore their social patterns of cognition and also visualize their realities with the frame of an AI-generated storyboard.

The approach consisted of two main components in the framework of an entrepreneurship-related project in Berlin. On the one hand, data from the entrepreneurial journey was captured using the SenseMaker® platform in order to generate triads and understand what triggered entrepreneurial responses and what drove their strategy. On the other hand, AI-imagery generation was used based on the entrepreneurial accounts captured by the SenseMaker platform. During the COVID19 pandemic, 18 entrepreneurs shared their story along with a structured survey response on the SenseMaker platform. This project took place within a university course based on entrepreneurial journeys from 2021 to 2022. The core of the project related to understanding the challenges that entrepreneurs face amid uncertainty. The respondents operated their startups in developing and developed economies, which include Germany, Colombia, Russia, Italy, France, and the United States. The involved sectors include Biomedical & Health, Food, Education, Event Management and Construction.

The SenseMaker tool supports mixed method data capture, and combines first-hand stories with quantitative data (Van Der Merwe et al., 2019). Research questions, core concepts and hypotheses are built into the instrument as signifiers. The latter refers to a framework of predetermined questions that support the researcher's analysis and inquiry regarding experience-based stories. In this sense, respondents were first prompted to share an experience with the question: "Looking back at the past couple of weeks, please share a work-related story about the impact of the COVID-19 pandemic on you and/or your organization." Once this story was shared, the respondents were then invited to make sense of their own stories through a process of signification on geometric shapes and sliders which test specific concepts and hypotheses.

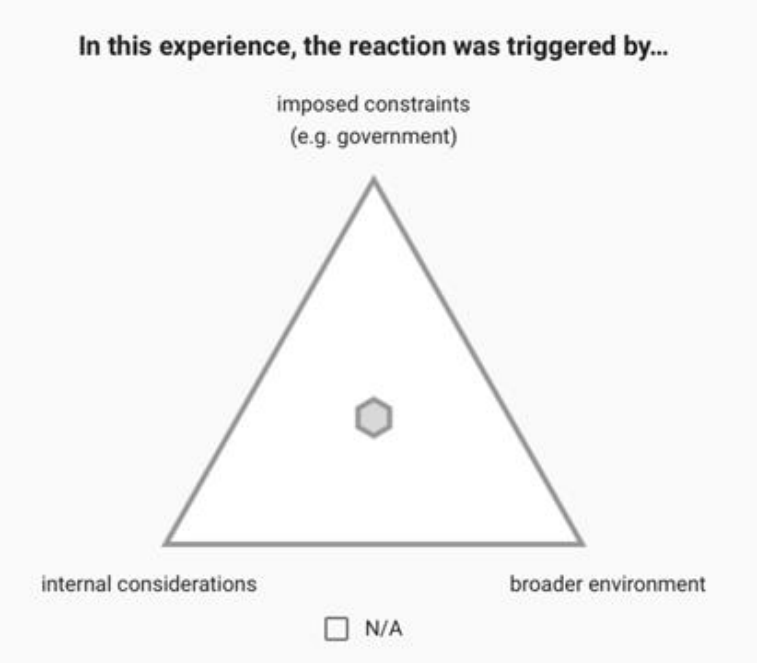

Figure 2. *Triad used in signification process.* A SenseMaker triad is a type of signifier question. In this example, the triad tests the factors that respondents were most influenced by. This triad considers the entrepreneurs needs to balance between their internal considerations, imposed considerations, as well as what they are observing in the broader environment. This triangle signifier forces the respondent to be more descriptive of their story and factors in the trade-offs that are necessary in decision-making. The apices of the triangle are framed as neutrally as possible, eliminating positive/negative influence from how responses are typically chosen. The way in which the respondent places their story results in background numerical coordinates that couple quantitative data with the qualitative story.

As seen on Figure 2, the use of triads provides linked qualitative and quantitative data that can be assessed in parallel. In doing so, the signification framework allows for patterns to reveal themselves over a body of stories, allowing the researcher the ability to view patterns of underlying relationships, norms, and dynamics without losing the descriptive value of the story. (Van Der Merwe et al., 2019, p.3).

In our analysis, we focused on 2 triads: (1) evaluating the influencing factors that entrepreneurs balanced against in responding to COVID-19 (internal considerations, external imposed considerations or broader environment), as well as (2) how this impacted on their overall strategy as they moved forward (whether strategy followed same patterns as before COVID-19, repurposed around emerging needs, or moving to support parallel industries). Table 1 summarizes the results.

Table 1. Results of Sensemaking Triads in percent. In more than half of the cases, reactions were triggered by imposed constraints during the pandemic, while the entrepreneurial strategies revolved around repurposing the business according to market needs. A third of the startups considered continuing as before.

Reactions were triggered by…		**The strategy was driven by**	
Imposed Constraints	50%	Repurposing around emerging market needs	56%
Internal Considerations	28%	Same as before	33%
Broader environment	22%	Supporting parallel industries	11%

The results from the SenseMaker output revealed that respondents' reactions were mostly triggered by imposed restrictions, and that this generally had an impact on them shifting their strategy to repurpose around emerging needs. With this understanding in mind, we were able to identify key stories that were indexed to exemplify these key patterns, as seen on Figure 3.

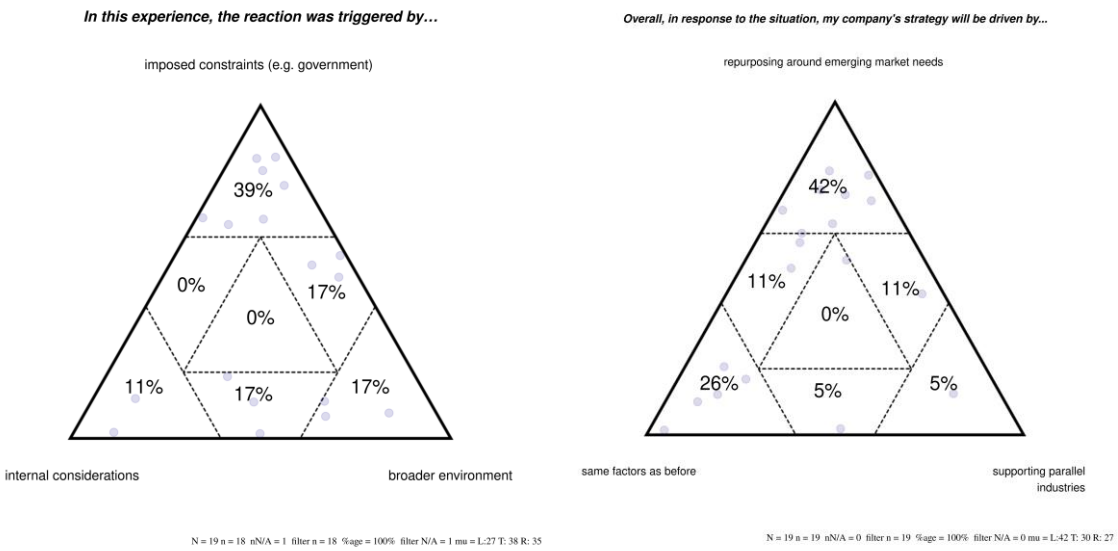

Figure 3. *Sample Triads.* The figure shows two triads and the corresponding slider distributions which were used to later generate the prompts. On the left, entrepreneurs were asked to consider what triggered their reaction. On the right, entrepreneurs were asked to consider potential strategic aims.

For the second part of the project, and following the development of the triads, a prompt was derived from each entrepreneurial story in order to carry out a visualization exercise. The stories, whenever necessary, were translated initially using Google Translate or DeepL and then further revised by a native speaker in English (US) with a C2 proficiency in the language of origin. The prompt was introduced along with two components of the SenseMaker survey, i.e. "The reaction was triggered by…" and "the strategy is driven by…". The final texts were introduced into Midjourney, a generative AI software that provides four visual proposals. The following box shows the structure of the prompt using solely the image category of storyboard, a relevant type of visual in the creative industries (Akleman et al., 2015).

For prompt: \imagine **prompt** storyboard of the experience of entrepreneurs in [country] managing through the COVID19 pandemic. An entrepreneur has shared this story to illustrate the experience [story] and has indexed their experience as [index 1] and their strategy influenced by [index 2]. ar 83:49.

This helped construct a variety of different entrepreneur personas (bringing in representation from different countries and industries) in order to develop visual stories that could be compared for context and texture. The following is an example of a visualization of an entrepreneur's experience. For all visualizations and their corresponding story prompt, cf. Appendix.

Figure 4. *Sample Visualizations of Entrepreneurs.* The image was produced using Midjourney.

The visual on Figure 4 depicts the story of a Colombian entrepreneur who narrated how he was facing considerable difficulties, let alone the complexity of the pandemic. The idea of internationality appears in the upper projection of a world map above a skyline, possibly representing the international orientation of the startup.

While the visualization via storyboard generated unintelligible text strings inside the conversation boxes, the interest lay in how the machine interprets the story visually. The story elements of place (setting) and characters appear present, yet the dynamic development of the story, i.e. the conflict, is not necessarily clear, neither on this visual nor on any of the other 17 exhibits. When linking this void to visual representations that operate in public spaces (e.g. murals), the AI generated storyboard would miss one essential element that public art represents, i.e. the transformative nature of the process. What Hamilton (2016) calls the "juxtaposition of periods" is hardly visible in the storyboards, even if they are supposed to represent a timeline.

Figure 5. *Sample Visualizations of Entrepreneurs.* The image was produced using Midjourney.

As seen on Figure 5, which regards the narration of an entrepreneurial journey in Germany, the story element of setting is clearly shown, even that of multiple characters, yet the sequence of occurrences that the storyboard is expected to show, is hardly recognizable. Instead, there is an atomization of non-sequential scenes that depict character interactions without a particular result or visual anchor, speaking again for a lack of transformative elements in the visual. The context, i.e, the pandemic, is made visible by the use of face masks, as in Figure 4, but how it relates to the story is unclear in the visual with regards to the journey dynamics.

DISCUSSION AND IMPLICATIONS FOR POLICY

The rise of generative static and dynamic AI-visuals and further technologies, for example, in sensemaking, offers potential when it comes to visualizing startup journeys for the sake of a more efficient understanding of the lifeworld of relevant actors, in this case entrepreneurs. In order to reconstruct what they go through, a helpful path is to capture weak signals in the stories told by entrepreneurs. This was made possible using the SenseMaker platform, which then allowed for the construction of input for AI-prompt generation.

Under the assumption that policymakers will show agency if the input received for policy formulation is clear, visual storytelling appears as a tool that eases the process, yet it does not guarantee that the crucial story elements will be depicted. This signals a weakness with regards to static visuals and suggests a cognitive advantage for dynamic visuals (e.g. AI-generated videos, which gained popularity following OpenAi's launch of SORA in early 2024). Static visuals such as storyboards, however, do portray other story elements such as character and context. This may serve as an initial input to spark a discussion with policymakers, provided they understand and translate the problems in the entrepreneurial process, e.g. complex unnecessary bureaucracy, into a solution that eases public value generation. A way to improve the process may involve aesthetic design heuristics (Ruiz Córdoba & Maya, 2022), which ease the process of cognitive processing.

Following the combination of the two mentioned tools, it seems clear that visualization without a process of sensemaking may fail to transmit the essentials of a story, let alone contribute to any successful policy building process. The successful transmission of the entrepreneurial journey is surely not limited to sensemaking, meaning that further tool combinations may offer other interesting results, having in mind that cognitive ease will be essential to maintain the attention of relevant policymakers. In this sense, visualization itself is no guarantee that the elements of a story will be appraised in a predictable intersubjective way, which matters when it comes to formulating better policies to support entrepreneurs. This implies that the input generated for better visuals must be curated in a way that the story elements are not only clear, but also *intersubjectively* clear, i.e. that the policymaker actually understands what the entrepreneur goes through as he or she lives it. In other words, if the storyteller's audience understands what the storyteller goes through, the story may "stick" (Heath & Heath, 2008).

Policymakers thus have tools at their disposal that can be used to better visualize and understand the realities that their relevant actors face. They need not be complex and long documents that will be unrealistically appraised in detail to provide solutions, meaning that attractive, well told, curated visual elements and accompanying information can be valuable

input when time and attention are scarce. In a way, this exercise of visualization is not distant from the traditional approach that a politician takes when interacting with potential constituents and collecting their stories. This exercise is a way of doing this more systematically while not forgetting the importance of cognitive ease, so that weak signals of the told stories are successfully captured and turned into policy inputs.

Our approach has several important limitations that further research may consider. We have only taken the perspective of the storyteller, i.e. not that of the policymaker, which implies that we have not accounted for the extent of intersubjective understanding of the visuals. On the other hand, this paper has not addressed the depth of entrepreneurial policy itself and how these economic actors interact with policymakers. Further, the prompts used were derived from a small set of stories that may not be considered representative of a bulk of entrepreneurial journeys, as they occurred during a major crisis and cover six countries. Also, the combination of these tools is a pragmatic, exploratory exercise that seeks to illustrate how modern policymaking can use technology and capture weak signals, yet this implies that we do not make claims about having the optimal tool combination, nor that the chosen storytelling form (the storyboard) is the best. A visualization in dynamic form, e.g. the creation of an AI-generated video, may be more promising. This implies that further research can observe how other Ai-generated visuals interpret other journeys, ideally comparing static vs. dynamic visuals, as the quality of both is improving at a fast pace.

CONCLUSIONS

This paper has attempted to combine two tools in order to visualize entrepreneurial journeys as an example of how storytelling serves the purpose of better communication, albeit indirectly serving further potential purposes: the creation of public value through better entrepreneurial policies. Departing from the 18 stories collected during the COVID19 pandemic, weak signals in the stories point to reactions having been triggered especially by imposed constraints, while the majority of the companies opted for a strategy of repurposing their business. Adding an AI-generated visual through a storyboard, their compelling stories became artifacts that may enrich discussions and interactions with policymakers. One difficulty, however, will always result if there is not enough political will to improve policies, even if the input from the relevant actors is there. However, improving the input with the mentality of cognitive ease may bring benefits in the interaction with policymakers.

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Appendix

AI-powered visualizations by startup. The visuals are presented with the name of the country where the startup was founded along with an index representing the number of the startup.

Colombia 1

Colombia 2

Colombia 3

Colombia 4

Colombia 5

Colombia 6

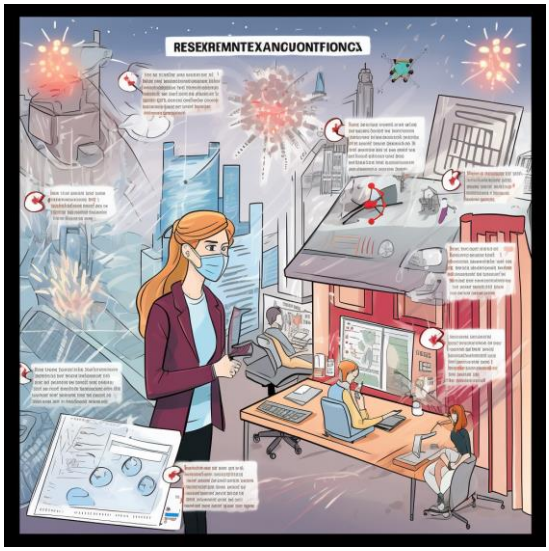
Colombia 7

France 1

Germany 1

Germany 2

Germany 3



Germany 4

Germany 5

Italy 1

Italy 2

Russia 1

United States 1

Colombia 8

Story Repository

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
Germany 1	A big part of our business had to do with offline events (we focus on education + networking). It fell apart as offline events were obviously not allowed anymore during the pandemic.	Internal considerations / Broader environment	Repurposing around emerging market needs
Colombia 1	We work in the construction sector. Due to sectorized quarantines in Bogota, our construction projects have shown delays for several reasons. For example, contractors living in quarantined areas were not able to come to work, suppliers delayed the delivery of materials, supervising personnel were isolated for covid testing, special working ours have changed our working schedule, reducing one hour a day plus the time lost on biosecurity protocols.	Imposed considerations	Repurposing around emerging market needs
Colombia 2	My entrepreneurship is called Detox Juice Green Shakes. It has always had social networks as a communication channel, not only to make us known but also through these social networks, sales were generated. Before the pandemic, we managed to open distribution channels in different establishments where the product was useful,, but following the Covid pandemic, these distribution channels had to be closed since they were not essential establishments. This caused us to run out of these distribution channels of our product. After this, we focused all the attention on digital social networks as the only sales channel, learning from the market, network marketing and other tools in which we support each other. We already had this when we had physical sales channels. We saw an opportunity in the midst of the crisis and took advantage of the digital media to leverage and generate sales.	Imposed constraints	Repurposing around emerging market needs

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
Italy 1	On the level of the small business, the difficulties and problems that we have are surely very different to those of the big companies. They are simply different concerning the impact and how we face the situation. The big ones are supported by the State, and the small ones are abandonned to their own responsibility, and since they are sometimes part of a family in Italy, it is more difficult, and everyone has to work hand in hand, facing difficulties, working more, solving problems. In 2009, we had a flood in Christmas, everything under water, and then we started over, buying the labels, new machines. We had more than 200.000 euros in losses, and then also the financial crisis came. We overcame the crisis with products of high quality, looking for a different market segment, with projects and adaptation of our pesto production. It is difficult when the supermarkets want a product because they need the big brands like Barilla, and now in the pandemic, the problem is the lack of dialogue with people, because our business is about providing good services, so the lack of contact, we could not introduce ourselves to new companies who do not know you, but we still have to work with our face and our seriousness to transmit our feeling, otherwise, with contact via zoom, everything is reduced to looking at a catalogue, prices and not the person. The first 2 months, we had uncertainty: what do we do now? we had a loan and were not selling our products, so we had to go to the bank to ask for more and have a personal loan, we had to speak to three banks who wanted to lend money to us in September, but we needed it in May, that means right now. Some clients who bought 100 to 150 kg pesto, we had to send them 10 kg with the same logistical costs otherwise we would lose them. Do i feel fear? yes, with banks, suppliers and clients. You feel so much uncertainty, everything is doubt, the house I had bought now served as bank warranty, and the State forced us to pay the same taxes as if nothing had happened. We had to pay property taxes, VAT, and then 20.000 eur for the property at which I cannot produce anything... A serious State should understand what it should do. They should have created more beds in the hospitals instead of creating temporary solutions that are a waste of money, not investments for the future. Banks were charging 2% interest while they got it for 0%.	Imposed constraints	Same as before
Germany 2	In general, running a business for me means to deal with new challenges on an every day basis. Most of them are just annoying, easy to solve or not overly complicated. We, as many other businesses in the Food & Beverage industry have been highly impacted by the lockdown measurements. We solved this in moving our business online and transferring resources to make our online shop presence more appealing and better in regards to content, UX and design. Unfortunately on the 10th of March we have been informed that our whole website, including all content, user information, site structure and banking details burnt down. We had stored the site and the back up system with a globally operating cloud service provider who was running a data center in Strasbourg, France and that very data center burnt	Imposed constraints	Repurposing around emerging market needs

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
	to the ground. Obviously the impact was massive as we lost the last functional business column carrying us through the crisis. Nonetheless we are used to getting shit done and we therefore managed to set up a new shop on Shopify within 24hours and although this shop showed only a fraction of our product, the information around the product and the services we provide, we had a new starting point. Now after six weeks the site is very much alive, new services have been integrated and we have almost reached the level of sales we had before we burnt down.		
France 1	As a producer of flours and flakes for human consumption (mostly based on wheat, spelt, rye, oat and barley), we faced a dramatic explosion of demands from our food retailing sector, starting in March 2020 in France, when the the French Government proclaimed a first Lockdown. Paradoxically, our major logistic partners suffered under a massive demand dreakdown and tried to raise their prices on certains routes that suddenly had no back-routes to book. This situation occured again in November 2020, during a second breakdown. As demand overtook again our production capacities, we decided to establish a "quote" system, allowing a certain amount of trucks per week for each warehouse. This regulation did not satisfy our client procurement departements, but it was necessary and in the end, we were proud to have delivered every order made during the period, avoiding larger sold-out situations that could have endangered our contracts and trading-relations. Unlike the first lockdown, schools kept open in November 2020, so that families did not stay entirely at home. Consumption habits did not change radically compared to a normal season, nore the baking habits. Finally, our food retailors faced a large over-stocking problem after the end of the November lockdown. After great turnover in November, December and January became very quiet.	Imposed constraints	Repurposing around emerging market needs
Colombia 3	Covid-19 has been a huge impact on our organization with both positive and negative outcomes, it has allowed us to understand that the internet is here to stay and more importantly, is here to help us communicate better. Throughout the pandemic we as a construction organization had the opportunity to understand that meetings could and will be held electronically, allowing for biding processes to be handle faster and more efficiently. As in the past, normally we would have to travel around the world in order to conduct meetings for possible projects, now days due to the pandemic it allowed us to understand we could have meetings that would accelerate the bidding and research [process of projects.	Internal considerations	Repurposing around emerging market needs
United States 1	Actually, COVID-19 was a blessing in disguise. We started our company during the pandemic, and so far we´ve been tremendously successful.	Broader environment	Repurposing around emerging market needs
Colombia 4	I am an entrepreneur who created his microenterprise 7 years ago. The year 2020 thought that it was going to be very good, we were growing and that is why we hired new staff and invest	Imposed constraints	Supporting parallel industries

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
	in opening a new market. Today the panorama is not encouraging, we had many losses, our customers stopped working, even one of the most important died of Covid, negatively impacting their company and therefore our commercial relationship. Today the numbers talk about a reactivation, but not powerful enough to recover what the pandemic took. There are fears and uncertainty and we have lost the focus, we are not clear about the course of action to follow.		
Germany 3	Germany is implementing new resctrictions regarding the coronavirus pandemic as of the 16th of december, 2020. This means that schools and kindergardens will be closed. In our company many people have kids, so they need to stay home and take care of their kids. Our company decided to provide all office workers, who were affected by new restrictions, with laptops. In this case people could work from home.	Imposed constraints	Same factors as before
Colombia 5	We have been a virtual company since 2010 and have monthly face-to-face meetings. Our customers were facing a big demand and it was already difficult for us from the middle of March. Fear spread and fixed costs took the air and company. But out of this came a push for digitalization and since then we have less business travel but more performance in working hours. Furthermore, we have had a better carbon footprint since then.	Internal considerations	Repurposing around emerging market needs
Colombia 6	The beginning of the pandemic was quite difficult, more than anything because of routine changes. My venture was simply aimed at giving all people or organizations a space that were focused on helping others. I simply had it as a directory, and the social networks that acted as a service to give visibility to the causes (the little visibility is one of the largest problems that the foundations have). Following the pandemic, many people began to contact me, people who were having a bad time, many writing that they had no roof for their families or anything to eat. At that time I thought that I could do something bigger, something that could have a greater impact on society, in this way I decided that we willñar should take another course. Within the platform there are 3 main users: foundations, entrepreneurs, subscribers. The foundations can create their profile, create publications, tell us what they do, why they do it, if they have events and how we can help them. On the other hand are the entrepreneurs, where they can publish their entrepreneurship and their products, with the only condition that a percentage of their sales (they can choose which one) is aimed at one of the causes recorded on the platform, in addition to this we will advertise to your ventures within our social networks. Finally the subscribers, who can come into contact with entrepreneurs and foundations, comment and link with the projects; In the future we want to gamify the platform, where rewards are granted for each action you perform: "You helped a puppy", "Don", "you performed volunteer." The pandemic helped me to direct my project on another way, a path that I hope and I want to impact the lives of many people.	Internal considerations	Supporting parallel industries / Repurposing around emerging market needs
Italy 2	my father, founder and CEO got infected back in december, other than the profound family grief from the situation, the	Imposed constraints	Repurposing around

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
	company faced a credit crunch from banks and providers, lack of confidence from stakeholders, including employees but after a few weeks (he's still in the hospital) his situation helped the team come together and implement changes that will prove to be good for the company in the long run.		emerging market needs
Colombia 7	It has taken a year. On a saturday morning of March 21st 2020, we decided to challenge the engineering team and we decided to build mechanical ventilators. Since we started that development, it has been like if we lived in a paralell wolrd. While everybody suffered the lockdowns, we kept working, even harder than before to develop our own mechanical ventilator, even when we knew nothing about mechanical ventilation. In the personal side of things, we have had some of our coworkers infected by covid-19 as well but fortunatelly they have all come out ok from their illness. However and unfortunately, some relatives from our coworkes have died due to Covid and their existing co-morbilities, which has greatly affected everyone´s mind health. The pandemic is almost gone, and regulations and "uneducated burocracy" in Colombia made it imposible for us to put a product in the market for pandemic pourposes. This has created a lot of stress on our small company cash flow which we are still trying to ease. Nevertheless, we continue working to be able to develop a product in the long run, which can be good for the worldwide market in the future.	Broader environment	Repurposing around emerging market needs
Russia 1	The demand for the ritual services we provide in Togliatti, Samara region, in the Russian Federation, from the late 2020 until early 2021, increased by 30 %. New offers of goods that meet the increased safety requirements have appeared. In February-March 2021, the demand decreased, which indicates a slowdown in the spread of the disease or the appearance of immunity in the population.	NA	Same factors as before / Supporting parallel industries
Germany 4	We are a medium sized whole sale company for fresh and chilled food in the west part of Germany. Located close to big cities like Duisburg, Essen and Düsseldorf. During the pandemic we noticed disrubrion from products for the out of home market to self service products for home comsumption. Taking in consideration that through the pandemic influence there should be a lot of people with unstable working situations, we have been optimistic to hire new qualified people. We send out job announcements to every well known job websites and the central employment agency. For the assistant in our quality departments (part time) we received 2 applications. One from a guy who is 34 years old and unemployment since 5 years. He does not even had the minimum qualifications for an office job at all. The other application came frome a lady that lived in Maroko and had no work permit for Germany. 2 candidats has been contacted proactive via social media like linkedIn and Xing. Both of them ask the near the double salary what was in budget.	Imposed constraints / Broader environment	Same factors as before
Germany 5	After my birthday, I got COVID with my mother and my brother. Even though I hadn't smoked in more than two years, I felt coughing as I had never quit. Coughing and a sore throat are	Internal considerations /	Same factors as before

Country	Story for Prompt	Reaction triggered by ...	Strategy driven by...
	two terrible foes for a language teacher, so I had to cancel classes for two weeks. After I got negative for covid, I still coughed and had to tell my students to understand my health issues. It has been quite an uncomfortable month.	Broader environment	
Colombia 8	The pandemic has affected the economy in general, which behaves as a domino effect for us, reducing many sources of income. In my case this year they could not hire more people again in the company.	Broader environment	Same factors as before

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APPLICATION OF E-LEARNING PLATFORMS BY HIGHER EDUCATION INSTITUTIONS DURING THE COVID-19 PANDEMIC: THE POLISH PERSPECTIVE

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Abstract: *Contemporaneity, in its complexity, brings progressive and degressive factors that shape the lives of organisations and individuals. Covid-19, as an unforeseen black swan event, was a massive challenge for universities in Poland and around the world. The education system has been transformed as digitisation of documentation and the use of online platforms during classes have become the only way to maintain the continuity of the education process. This article aims to evaluate the effectiveness of technology during the COVID-19 pandemic within the Polish context and to identify potential future opportunities for digital transformation in university teaching through the virtualisation of education. The hypothesis put forward in the paper is that the black swan of Covid-19 and the resulting technological boom have sparked the acceleration of change in higher education. The research data were obtained from secondary and primary sources, using qualitative and quantitative methodology. Using the Web of Science and Scopus databases, the desk research method was used. A diagnostic survey using the Computer-Assisted Web Interviewing (CAWI) technique was used to obtain the primary data. The research findings reveal opportunities for virtualising teaching processes in higher education through e-learning platforms beyond the pandemic.*

Keywords: *virtualisation, e-learning platforms, Covid-19 pandemic, digital university.*

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INTRODUCTION

The modern economics is based on the digital revolution and information management. Its special feature is the speed of information delivery. Numerous studies state that the Covid-19 pandemic has accelerated the processes of digitisation and informatisation in many sectors (Crawford, 2022; Chytilová et al., 2024). These studies reveal a globally accelerating pace of digital transformation across diverse sectors, including healthcare, education, social welfare, public administration, IT, manufacturing, trade, and services (Bilan et al., 2023; Maama, 2024; Schilirò, 2020). These profound changes are affecting both private and public sectors, and apply to small, medium and large organisations (Agostino, 2021). Thus, it is worth looking at the general transformation processes occurring in organisations and management in general, and then try to isolate the specific changes occurring in higher education (Sułkowski, 2020).

The COVID-19 pandemic has dramatically altered both organisational behaviour and consumer attitudes (Alhaimer, 2022). The pandemic has accelerated the shift from traditional, face-to-face organisational interactions to remote and hybrid models, fundamentally altering organisational behaviour, culture, and identity (Spicer, 2020; Mishchuk et al., 2023).

Covid-19 is a catalyst for many changes in higher education. Its primary impact is the accelerated digital transformation of universities, resulting in the emergence of a new digital university model as academic activities shifted to the virtual realm (Hemaswetha, 2022; Davidovitch & Eckhaus, 2022). The university's mission can be accomplished through online communication, although this is not free of certain limitations related to the effectiveness of education. There has been an organisational, technological, social and cultural change that allows the university to educate, conduct research and collaborate with the non-academic environment online. Didactics has undergone a strategic shift characterised by a dramatic increase in the prominence of e-learning and the virtualisation of education. The transition to online education presents significant challenges for both administrators and educators. Synchronous systems such as Teams, Zoom, Meet or advanced specialized LMS platforms are being used, providing opportunities for synchronous and asynchronous e-learning and better control over the verification of learning outcomes and the quality of online learning. The field of learning is experiencing the growth of international and national collaborative networks, resulting in high-impact publications and implementations. Professionalising university management involves training and developing specialised managerial roles, such as financial management (chancellors), academic administration, and knowledge management (Camacho-Javier, 2022). The digitisation and virtualisation of universities is taking advantage of increasingly complex systems that communicate, process, collect and analyse data and manage all aspects of university operations.

The Theoretical Background of Education Virtualisation

The education sector has undergone a profound metamorphosis into remote learning (Arokiasamy, 2017; Kang, 2021; Staniec et al., 2023). Covid-19 has resulted in a forced transition of universities to remote learning on a global scale (Kulikowski et al., 2022). To date, e-learning has primarily been integrated into higher education as a blended learning approach, supplementing traditional face-to-face instruction delivered by academics. Most

universities around the world have the necessary programmes for this, although they are marginal to traditional forms of learning. A smaller number of universities before the pandemic based their offerings primarily on e-learning. Examples include: Open U, Embry-Riddle Aeronautical University-Worldwide, Temple University, University of Oklahoma, Arizona State University, Western Kentucky University (top 5 online bachelor's programs). In the best developed higher education systems, there is a growing trend toward VLE (Virtual Learning Environment), which, combined with Managed Information Systems (MIS), form a control system for the e-learning environment (Managed Learning Environment). LMSs, in turn, allow not only synchronous and asynchronous e-learning, but also the management of quality and the online learning process (Olubiyi, 2024; Sułkowski, 2021).

Another effect of the changes is that the higher education sector is facing financial challenges in many countries. According to a survey of students in the U.S., a significant percentage expect a significant reduction in tuition fees if education is delivered online, which could have significant implications for university budgets (Burki, 2020). Deteriorating financial conditions in higher education could result in university closures and a surge in mergers and acquisitions (Rakshit, 2020).

The literature points to several ways of understanding digital transformation in universities (Benavides, 2020; Jackson & Konczos Szombathelyi, 2022). A review and systematization of definitions and change areas identifies key themes: change management, digital transformation, educational innovation, customer focus, and new business models (Matt, 2015).

Digital transformation is a process of change in a university and involves people, projects strategies, structures understood dynamically (Rodrigues, 2017). Digital transformation is a process that aims to change an organisation holistically through a combination of information, computing, communication and connectivity technologies (Vial, 2019). Digital transformation goes far beyond dematerialisation of processes to include innovative use of new technologies to promote new services, redefine business models and interact with users (Faria, 2020). Digital transformation is the process of creating and implementing innovations that change the market and organisations, leading to new solutions (Hinings, 2018). Digital transformation of the higher education system should focus on a broader range of challenges and must include modernisation of ITC architecture management, which could significantly contribute to innovation in education (Kaminskyi, 2018). On the other hand, higher education should also be the place where new skills are taught, those which will prepare people for digital transformation (Jurczuk, Florea, 2022). One can observe a rapid increase in research on Digital Transformation in higher education in recent years. There is a growing interest in the implementation of ITC solutions in university operations, which are moving towards a digital University (Bond, 2018). A key aspect of university digital transformation involves leveraging modern IT solutions to modernise the educational system, which includes integrating digital technologies into teaching, learning, and administrative processes (Potjanajaruwit, 2023). Among the frequently explored topics are: the didactics of e-learning, the use of information and communication solutions in education, the analysis of digital interaction and communication in the learning process (Androutsos, 2019).

Summarising the various interpretations of digital transformation in higher education reveals several common themes in the literature. First, digital transformation is treated as a breakthrough process, leading to profound changes in many aspects of university operations.

The multidimensionality of the changes brought about by digital transformation includes aspects of: organisation and management, pedagogy, infrastructure, academic culture and technology. Digital transformation is fostering innovation in university operations, including organisational structure, management practices, communication channels, teaching methodologies, research approaches, and implementation. Organisational structures within universities that are often radically reconfigured under the impact of digital transformation also include strategy and management: knowledge, human capital, marketing, finance, processes and projects (Mohamed Hashim, 2022). Digital transformation research in higher education is characterised by an inductive and analytical approach (Bygstad, 2022).

Covid as a catalyst for e-learning in higher education - SARS Cov-2 as a destructor and inducer

The Covid-19 pandemic has been repeatedly described in the literature as an unforeseen event, i.e. a "black swan" of socio-economic life (Glette-Iversen, Aven, 2021; Ahmadab Ali, Kutan, Gupta, 2021; Yarovaya, Matkovskyyb, Jalan, 2022). Changes have occurred primarily in healthcare, but also in business. The pandemic impacted the continuity of global supply chains, industries where direct contact with the customer is crucial, and of course in education. The pandemic posed significant challenges to the education of children and youth, placing immense strain on teachers in terms of pedagogy, organization, and instruction. Many people were unprepared for the demands of online teaching and learning. More than three years of experience have shown that, despite concerted efforts, the shift to remote learning has resulted in educational gaps, especially in the youngest children who rely on school not only for academic growth but also for essential social development and learning interpersonal skills.

However, from the point of view of higher education, the experiences of the pandemic are diverse. It can be stated from the conducted participant observations, as well as from the extensive literature on the subject, that higher education responded to challenges in a very diverse way - from a complete lockdown and conducting classes only with the use of remote learning methods and techniques, through the organisation of various hybrid classes (lectures delivered online, exercises and practical classes conducted in person with an academic teacher; part of the group participated in lectures in person, while those under quarantine could participate in classes remotely at the same time), to use e-learning tools to support the traditional teaching process.

From the point of view of the higher education didactic process, an equally important issue was an opportunity to indicate to future potential employees (participants of the labour market) that the skills of independent and remote work, as well as digital competences may become a priority for employers (Núñez-Canala et al., 2022; Zhaoa et al., 2021; Cahena, Mendes Borini, 2020).

It can therefore be concluded that the Covid-19 pandemic has caused bilateral transformations in the world of higher education. On the one hand, the pandemic has wreaked havoc on integration. Societal development and interpersonal relationships have suffered significant and alarming setbacks due to the pandemic. It will certainly be difficult to rebuild them, especially with a noticeable high level of lack of trust in interpersonal, business and institutional relations. On the other hand, the pandemic has shown that there are many

opportunities that have not been used at all or only to a limited extent. E-learning is one of such opportunities, which has been widely used as a tool supporting traditional didactic processes for a long time. Most often, this solution is called *blended learning* (Thorne 2003; Garrison, Vaughan 2008; Hew, Cheung 2014; Bonk, Graham 2006). During the pandemic, this educational model was often referred to as hybrid learning. This, of course, is an incentive to continue such a model of learning, especially in the context of business transformations. In the case of fields of study that most often educate for the needs of broadly understood business, i.e. management, economics, finance, logistics, it is important to respond to the demand by suitably organising work. Consequently, modern universities must prioritise cultivating students' independence, critical thinking, and technological proficiency to prepare them for the future.

The destructive nature of the Covid-19 pandemic also highlighted the problems of academic teachers, especially in the context of their digital skills, which significantly limited the options for using remote learning (Basilotta-Gómez-Pablos et al., 2022; Morze, Buinytska 2019; Sanchez-Cruzado et al., 2021; Pesha, Kamarova, 2020).

The utilitarian nature of science also manifests itself in the possibility of combining studies with gaining professional experience. Unfortunately, student digital competencies proved to be a significant challenge, primarily due to insufficient proficiency in using educational platforms and advanced IT tools (Arokiasamy, 2017; Kostikova et al., 2020). Surprisingly, while initially presenting challenges, the shift to online learning has also unveiled opportunities to develop essential future-oriented skills and competencies for the professional career.

The black swan COVID-19 pandemic developed into an unforeseen crisis, which triggered widespread disruptions, halted supply chains, caused raw material shortages, and the closure of transportation, tourism, and hospitality businesses due to prolonged restrictions and lockdowns are still being felt. However, on the other hand, Covid-19 may be an impulse for positive change in management and teaching processes, contributing to the creation of new standards of education quality, especially for the needs of the labour market. Remote work is rapidly becoming a legal norm in many countries, yet it presents significant organisational challenges for employers as they adapt to employee preferences (Bamieh, Ziegler 2022; Tyutyuryukov, Guseva 2021; Popovici, Popovici 2020; Geldart 2022; Rudnicka et al., 2020). Remote work introduces new challenges for organisational management, including recruitment and work conditions. A crucial aspect is effectively integrating innovative technological solutions into the educational process such as utilising educational platforms to enable and support remote learning.

Development of Learning Management Systems (LMS)

Learning Management Systems (LMS) are online platforms designed to facilitate and manage the online educational process. These systems are gaining popularity due to their ability to efficiently manage educational content, assessments, and communication between all participants in the learning process. LMS platforms are used in education (at various levels), in higher education and in enterprises as solutions supporting the process of self-improvement of employees. During the Covid-19 pandemic, LMS platforms played a special role by becoming a place of cooperation and implementation of educational processes.

The origins of LMS date back to the 1960s, when the first systems for managing research and publication results appeared at universities. The first LMS systems emerged in the 1970s, initially used in universities to provide students with convenient access to course materials and exam results. In the 1980s, these systems began to be used also in company training. With the development of technology and the Internet in the 1990s, LMS became more accessible and popular. During this period, platforms were developed that were more advanced and allowed the addition of multimedia educational content, as well as integration with other systems, such as content management systems and e-commerce platforms. With the development of e-learning (mainly academic), Learning Management Systems have become an integral part of the teaching and training process. The early 2000s witnessed a surge in LMS adoption, driven by the growing popularity of e-learning, increasing demand for online training, and the corporate training needs of businesses. This period also marked the emergence of fully responsive, mobile-friendly LMS platforms, enabling learners to access training on the go. These platforms empowered users to create courses and integrate them with social networks, fostering a more collaborative learning environment.

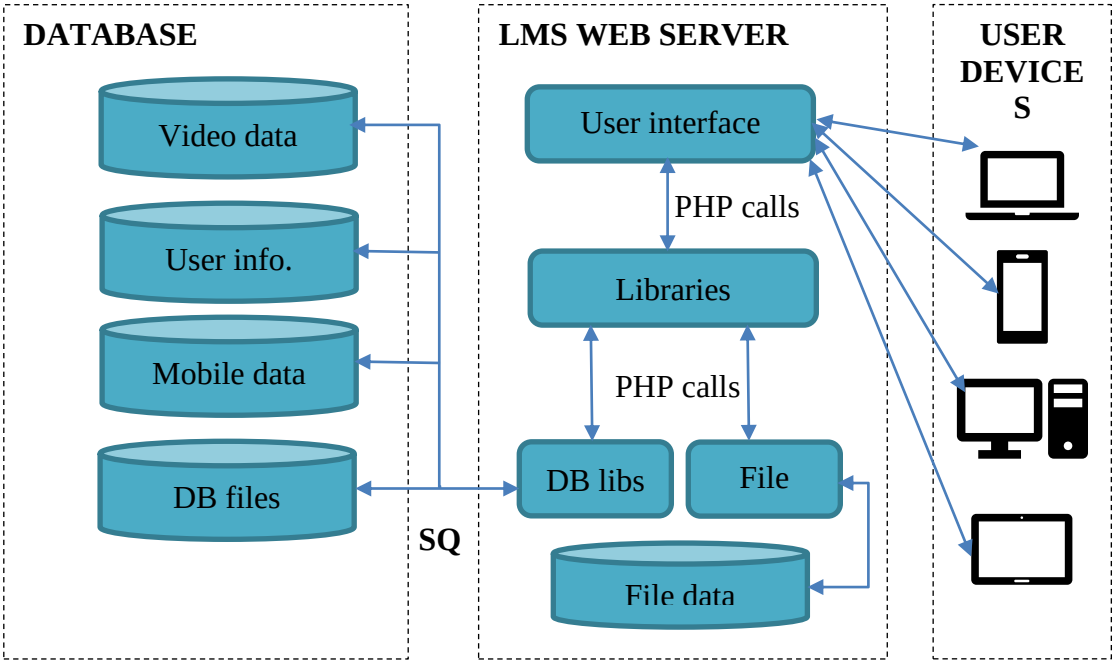

Figure 1. Typical learning management system structure

Currently, LMS continue to be developed and improved to meet the needs of participants of educational and academic courses as well as company training. Many LMS platforms offer a rich variety of learning tools such as quizzes, tests, videos, podcasts, interactive presentations, and more. In addition, Learning Management Systems offer more advanced data analysis functions that allow a user to monitor the progress of participants, track results and create reports.

There are several leading providers of LMS solutions on the market. Among them, the most popular are Moodle, Blackboard, Canvas, D2L and SAP Litmos. Each of these systems has its own unique features, offers different licensing models and pricing policies, and has its own advantages and disadvantages. Moodle is a free and open-source learning management system, which occupies a prominent position in the LMS landscape. Moodle is distinguished by its high flexibility and the ability to adapt to the individual needs of the organisation. It is open-source software, which means that it can be freely modified and adapted, which, combined with low costs of use, makes Moodle the most frequently used Learning Management System in the online education space.

METHODOLOGY

Primary explanatory research, focusing on a single topic, complementing secondary exploratory research, was conducted in Poland in May, October and November, 2022. This research aimed to assess the current state of digital platform integration in communication and education within higher education, as well as the level of acceptance for these innovations. The research focused on the experiences of higher education participants regarding the usefulness of selected digital platforms in communication and educational processes. The researchers wanted to find out how the respondents used selected digital platforms in communication and educational processes and how they assessed their functionality. The research is descriptive and explanatory. Descriptive analysis focused on characterising respondents' educational activities and the functionality of used digital platforms, assessing their communication and educational efficacy. Explanatory analysis aimed to verify hypotheses about the long-term viability of digital platforms in higher education. This involves identifying, determining, and evaluating the causal relationship between the application of digital platforms in education and their potential to enhance digital skills and competencies among higher education participants.

The diagnostic survey method was used for the study. Indirect research using the “user-centric” Internet was limited to the use of the CAWI (Computer Assisted Web Interview) online survey method. A questionnaire consisting of 26 closed questions, including 9 based on ordinal assessment scales, placed in a Google spreadsheet form was used as the visual measurement tool.

Due to the scope of the measurement, the study carried out can be defined as fragmentary and deterministic with characteristics representative for the surveyed population. The empirical material was obtained from primary sources, i.e. people with the status of a student (having a student record number) and participating in classes at universities operating in Poland. Not all students studying in Poland in the academic year 2021/2022 were surveyed, only a selected sample. The selection of units for the sample was carried out in two stages.

In the first stage of the study, out of 426 universities operating in Poland in 2021/2022 (according to POLON - System of Information on Science and Higher Education in Poland) constituting the statistical population of universities operating in Poland, $n_1=23$ statistical units were indicated in which the research should be conducted. The determination of the number was carried out based on the formula for the minimum number (1), with an indication of the components of the fraction 0.9 for universities that in the academic year preceding the

study, i.e. 2020/2021, used digital platforms in the education process and 0.1 for universities that did not use such solutions, 10% random error and a confidence level of 0.90.

$$n_{min}=NP(\alpha 2 \cdot f(1-f))/NP \cdot e2+\alpha 2 \cdot f(1-f)$$

where:
nmin – is the minimum sample size
NP – the size of the study population
α – confidence level for the results
f – fraction size
e – assumed maximum error

The operational method of stratified selection with proportional allocation with systematic sampling, taking into account the following criteria: public university (0.4) / non-public university (0.6) according to the number of universities operating in Poland in 2021, 23 universities were selected in which the study should be conducted - including 9 public and 14 private. The sample of universities was collected using the method of systematic selection with proportional allocation.

Then, in the second stage, the number of statistical individual units that were subject to the study was specified in the selected statistical collective units. Using the method of selecting typical units from the population of individual units at each of the indicated universities, those students who had the status of a student and used digital platforms during their studies in the academic year preceding the study, i.e. in 2021/2022, were indicated as study units. Again, using the formula for the minimum sample size, the minimum sample size of statistical units was obtained, this time for viable units - students at the level of $n_2 = 369$ units. The components used were the fraction of 0.6 for students who represented public universities and 0.4 for the others, with a random error of 5% and a confidence level of 0.95.

$$Z = n_2/n_1$$
$$Z = 369/23$$
$$Z = 16{,}043 \approx 17 \text{ viable units (students)}$$

Finally, it was assumed that at each of the 23 selected universities, at least 17 students would be asked to participate in the study (adjusted Z indicator expressing the ratio of the minimum number of students to the minimum number of university samples). Finally, after converting the total units, the minimum sample size was calculated at 391 individual units that should be tested. It was assumed that if a greater number of responses were obtained, it would work in favour of the study.

The study was conducted by sending invitation emails to participate to 23 universities. In this email there was a request to forward information about the study to the minimum number of students who agreed to participate in an anonymous study - that is, at one university it was 17 people. The email included a link that redirected to the research website.

Finally, consent was obtained from 528 students who filled out questionnaires from 23 selected universities as respondents. The collected material was archived in an Excel spreadsheet. Then, the raw data was encoded in the Statistical Package for Social Sciences (SPSS) software. The prepared material prepared was verified and validated. In the first stage, an analysis of the structure of the distribution of the values of the features characterising the study sample, i.e. the students participating in the study, was presented. A

comparative analysis of the collected material's sample characteristics in relation to the study population was conducted using a non-parametric chi-square test (χ^2) of correspondence.

$$\chi^2 = \sum_{i=1}^{r} \frac{(n_i - np_i)^2}{np_i}$$

where:
p_i — is the probability that the feature X will take a value belonging to the class interval
np_i — is the number of units that should be in the i-th interval, assuming that the feature has a distribution consistent with the hypothesis.

Statistics, on the other hand, have a distribution χ^2 α o k = (r - 1), where:
k — is the number of degrees of freedom
r — is the number of class intervals
χ^2 is the empirical value of the statistic obtained from the study.
The form of the critical set: P ($\chi^2 < \chi^2\alpha$) = α where $\chi^2\alpha$ is the critical value from the tables of distributions χ^2 for k = r - 1 degree of freedom and p = α.

Therefore, at the beginning, the null hypothesis (H_0) was adopted about the consistency of the distributions of selected variables (gender, level of education, mode of education) from the sample with the distributions characterising the general population of people studying in Poland, respectively, and the alternative hypothesis (H_1) about the existence of a mismatch.

Thus, in the surveyed sample of 528 respondents, women (55.4% of the respondents) dominated over men (44.6% of the respondents). The majority of respondents (61.4% of respondents) compared to men (38.6% of respondents). Most of the participants were aged 19-24 (47.3% of the respondents). More than half of the respondents (75.8% of the respondents) study at first-cycle and uniform master's studies, and more than half (62.5% of the respondents) are full-time students.

The analysis results indicate that the null hypothesis (H_0) was rejected. Therefore, the hypothesis H_1 about the compatibility of distributions is true, i.e. the sample of students from the selected universities coincides with the general population of all students in Poland studying in the academic year 2021/2022 in terms of the share of students by university status, gender, level and mode of education (Table 1). Regarding representativeness, a systematic random sampling method with proportional allocation was used in the first stage of the study, however, the second stage employed non-random selection of typical units. Consequently, due to the non-random selection of the n_2 student sample in the second stage, fully assessing the sample's representativeness in statistical terms is challenging. Nevertheless, the authors drew inferences based on the sample size.

Table 1. Sample representativeness - Statistical concordance test χ^2.

Item			Value χ^2	Value χ^2_α	Test realisation
	Number n_2	Number N_2	Real	Theoretical	$\chi^2<\chi^2_\alpha$
university status					
Public	346	813 564	0,792	6,635	concordance
Private	182	394 464			
Gender					
Female	324	708 788	1,576	6,635	concordance
Male	204	499 240			
Level of studies					

Ist-cycle and uniform master studies	400	939 173	1,204	6,635	concordance
II-nd cycle – master studies	128	268 855			
Mode of studies					
Full-time	330	774 423			
Part-time	198	433 605	0,592	6,635	concordance

[a] α – confidence level

Then, an analysis of the distributions for selected empirical variables from the main questions was carried out, and based on the measures of distribution location, such as the weighted mean ($\bar{\chi}_\omega$) and the mode (D_o) the platforms were compared according to the respondents' indications. In the case of determining the average values, the formula for the weighted average $\bar{\chi}_\omega$ was used, indicating the size of the weights in such a way that the elements of greater importance had a greater impact on the indicated average value in the form:

$$\bar{\chi}_\omega = \frac{\chi_1\omega_1+\chi_2\omega_2+\ldots+\chi_n\omega_n}{\varpi_1+\varpi_2+\ldots+\varpi_n}$$

where:
ω_i – was the weight value

In the next step, where it was possible and logically meaningful and statistically significant, the hypotheses about the existence of a relationship between the variables from the main questions and the questions of the metric were verified. Each time, an independence (contingency) table was constructed allowing to order two features simultaneously. The table consisted of r rows and s columns, with each row (column) corresponding to variants of the X (Y) feature. The contingency table consists of the nij numbers of those sample elements that have the i-th variant of the feature X (i=1,2, …., r) and the j-th variant of the feature Y (j=1,2, …, s). Then, in the second stage of the analysis, based on the contingency table, the null hypothesis (H_0) of the existence of stochastic independence of random variables X and Y and the alternative hypothesis (H_1) were verified.

The basis for the verification of the H_0 hypothesis of stochastic independence of variables was the value of the χ^2 independence test:

$$\chi^2 = \sum_i^r \sum_j^s \frac{\left(n_{ij}-\tilde{n}_{ij}\right)^2}{\tilde{n}_{ij}} : \chi^2_{(r-1)\cdot(s-1)}$$

where:
n_{ij} – empirical conditional numbers resulting from the contingency table,
$\tilde{n}_{ij}$ – theoretical conditional counts that would appear in the array if the features were independent.

Due to the fact that the rejection area H_0 is always right-sided, its size depends on the adopted α significance level. It is bigger, if α is bigger. It is generally assumed that α <= 0,05. Critical values of the distribution χ^2 o (r-1)*(s-1) levels of freedom. If only $\chi^2_{emp} > \chi^2_\alpha$ then H_0 is rejected in favour of the hypothesis H_1, which means that the pair of features are interdependent. In addition, the analysis of the obtained values when verifying the hypotheses was strengthened by the reference to Cramer's V coefficient

$$v = \sqrt{\frac{\chi^2}{n \cdot \min(r-1, k-1)}}$$

where:
V – Cramer coefficient between two variables,
χ^2 is the empirical value of the statistic obtained from the study for the pair of variables
n – number of observations
r – number of levels of one variable
k – the number of levels of the second variable
$\min(r-1, k-1)$ – the smaller of the two (r-1) or (k-1)

Using the above methodology, the process of testing the statistical significance of the relationship between the selected variables was carried out technically using the SPSS software. Each time, the verification of statistical significance for the indicated variables consisted in checking whether for the statistical value χ^2 of a given pair of analysed variables, the value of the parameter of asymptotic significance is lower than 0.05. If so, the observed relationship between the variables could be considered statistically significant, and the results and conclusions drawn on the basis of the analysis of data obtained from the sample were considered representative and could be used to form conclusions about the entire population.

The collected and analysed research material formed the basis for a comprehensive presentation in the subsequent part of the article, which led to conclusions and recommendations about the potential for virtualising teaching processes using e-learning platforms in higher education post-pandemic.

DISCUSSION

The research enabled an analysis of platform availability, the factors influencing platform selection, platform usage frequency, the frequency of using educational activities on these platforms, the effectiveness of platform features, overall platform functionality, and the technical capabilities of the platforms.

Respondents admit that when connecting to the Internet, they most often use a laptop and a smartphone (73.5%) or a desktop computer and a smartphone (18.6%). Definitely most often, that is, several times a day, the respondents connect on the Internet for private matters (92.8%). Similarly, the majority of respondents (70.1%) use the Internet several times a day for business matters. Respondents primarily use public messaging applications (96.2%), followed by social media platforms (80.7%) and SMS/MMS (75.8%) for private matters. At work, the respondents admit that they most often use email (78.8%), sms and mms (55.3%) and public messaging applications (49.7%).

In order to learn, the respondents use the Internet much less frequently. Most often they connect to the network several times a week (43.2%) or several times a day (30.7%). Respondents use various options, most often they use public messaging applications (93.2%), group messaging applications (89.8%) and email (76.5%). In the learning process, text messages are more often used by undergraduate students (19.3%). Similarly, email is more often used by first-cycle students (55.3%) and full-time students (46.4%). Public messaging applications (e.g. Messenger) are more often used by full-time students (48.7%). Similarly, these students more often use institutional messaging applications (e.g. company chats,

university chats) (24.5%). In turn, group messaging applications (e.g. Teams, Zoom, Google Meet) are more often used by students of public universities (58.8%), first-cycle studies (68.5%) and stationary students (56.2%). On the other hand, dedicated webinar platforms (e.g. ClickMeeting) are more often used by undergraduate students (13.6%) and part-time students (11.7%) in the learning process. Social platforms (e.g. Facebook) are more often used by students of public universities (27.7%) and full-time students (27.3%). E-learning platforms (Moodle, Blackboard Ultra Learn) dedicated to remote learning are most often used by students of private universities (19.1%), undergraduate students (20.8%) and part-time students (17.1%). The existence of the indicated relationships is confirmed by the χ^2 test of independence with the strength of the relationship determined by V-Cramer (Table 2.)

Table 2. Frequency of using digital forms of collective communication in education in relation to the status of the university, the level of education and the mode of education - test of independence χ^2 with the strength of the relationship determined by V-Cramer.

Item	University status			Level of education			Mode of education		
	χ^{2a}	p[b]	V[c]	χ^{2a}	p[b]	V[c]	χ^{2a}	p[b]	V[c]
1. Sms	1,531	0,675	0,054	16,295	0,001	0,176	5,258	0,154	0,100
2. Email	7,284	0,063	0,117	19,206	0,001	0,191	16,800	0,001	0,178
3. Group messaging applications	12,161	0,007	0,152	9,460	0,024	0,134	9,364	0,025	0,133
4. Public messaging applications	3,470	0,325	0,081	3,298	0,348	0,079	12,529	0,006	0,154
5. Institutional messaging applications	2,377	0,498	0,067	1,920	0,589	0,060	10,090	0,018	0,138
6. Dedicated webinar platforms	3,255	0,354	0,079	20,122	0,001	0,195	16,916	0,001	0,179
7. Social platforms	9,777	0,021	0,136	1,379	0,711	0,051	19,945	0,001	0,194
8. E-elearning platforms	18,294	0,001	0,186	30,762	0,001	0,241	23,094	0,001	0,209

[a] χ^2 – test value [b] p – asymptotic significance [c] The strength of the relationship calculated with the use of V-Cramera

Among the messaging applications that the respondents are familiar with and use most often, the following were indicated: Messenger (96.2%), Microsoft Teams (92.4%), WhatsApp (59.8%), SnapChat (34.5%), Discord (32.6%), iMessage (25.0%) and Zoom (20.8%). Other messaging applications operating on the market are used less frequently. These include Skype (20.1%), Google Meet (17.0%), Telegram (14.8%), Click Meeting (6.4%), Viber (6.4%), Slack (3.8%) %), Cisco Webex (3.4%) and WeChat (1.5%).

In turn, the e-learning platforms that are generally known to the respondents and which they have ever used include Microsoft Teams (72.3%), Zoom (36.0%), Moodle (17.0%), Blackboard UltraLearn (15.9%)) and Google Classroom (14.)%. Other Platforms operating on the market or known to a small number of respondents, including Adobe Captivate Prime (4.9%), Navigator (4.5%), Cloud Academy (2.7%), Asseco (1.9%), Edmodo (1.9%), Cloudlabs (0.8%), Business Simulation (0.4%), Cyberskiller (0.4%), Edu Web360 (0.4%), Inspera (0.4%) and Navoica (0.4%). The others are completely unrecognized (Docebo, Litmos, Parlo, Revas and Universality).

Taking into account the most frequently used dedicated learning tools, i.e. e-learning platforms, an analysis of their use and assessment of their functionality and usefulness from the point of view of users will be presented below.

In the era of Covid-19, respondents could use more than one e-learning platform. When asked which e-learning platforms the respondents used in the years 2020-2022, the respondents most often indicated Microsoft Teams (88.3%), Zoom (42.0%), and Blackboard UltraLearn (16.3%). Only a small percentage of respondents indicated the Moodle platform (10.2%) and Google Classroom (8.0%). Respondents admit that the Microsoft Teams (93.5%), Blackboard UltraLearn (93.0%), Moodle (81.5%) and Google Classroom (42.9%) platforms were chosen by the universities where they studied or organisers of events in which the respondents participated. Only the Zoom platform was indicated by the respondents as the one used by the respondents and which they chose themselves (11.7%) or the institutions where the respondents worked (28.8%).

Table 3. Frequency of using educational activities available on selected platforms by respondents (D_o value).

	Google Classroom [a]	Blackboard UltraLearn [a]	Teams [a]	Moodle [a]	Zoom [a]
Item					
1. Lecture	3	4	4	2	2
2. Videoconference	2	3	3	1	2
3. Practical classes	2	4	4	3	2
4. Conversations	2	4	3	2	2
5. Decision games	1	2	1	1	1
6. User manual	1	2	1	1	1
7. IT labs	1	1	2	1	1
8. Project method	1	1	2	1	1
9. Simulations	1	1	1	1	1
10. Seminar/ webinar	2	2	2	1	1
11. Case studies	1	1	1	1	1
12.Workshops	2	2	2	2	1
13. Consultations with lecturers	2	3	3	1	2

[a] for the frequency scale from 1 to 4, where 1 means never, 2 rarely, 3 sometimes and 4 often

Analysis of the measure of diversification of the most frequently occurring feature marked with the dominant (D_o) for the use of platforms (with frequency markings from 1 to 4, where 1 meant never, 2 rarely, 3 sometimes and 4 often) in individual forms of educational activities (Table3.) Respondents' choices show that the Blackboard UltraLearn platform was most often used, apart from lectures, in conducting practical classes or conversations. Sometimes this platform was used in the implementation of video conferences and consultations with the hosts. This platform was rarely or never used for other activities. Similarly, Microsoft Teams was most often used, apart from lectures, for practical classes. It was sometimes used for video conferences, conversations and consultations with lecturers. Other activities were rarely or never supported by this platform. The Moodle platform was sometimes used to conduct practical classes. On the other hand, the Google Classroom platform was sometimes used to conduct lectures and it was generally rarely used for other

activities. The last of the educational platforms, Zoom, was used by far the least and, if at all, for lectures, video conferences, practical classes and conversations. To sum up, the above results show that activities carried out on educational platforms are derivative of those activities that most often occur at universities.

Table 4. Evaluation by the respondents of the features available on selected platforms ($\bar{\chi}_\omega$ value).

	Google Classroom [b]	Blackboard UltraLearn [b]	Teams [b]	Moodle [b]	Zoom [b]
Item					
1. Ability of instructors to enter information	3,26	3,69	3,93	3,38	3,52
2. Placement of teaching materials	3,16	3,76	4,09	3,35	3,53
3. Availability of virtual libraries	3,15	3,18	3,47	3,11	3,51
4. Availability of video materials	3,26	3,63	3,75	3,25	3,50
5. Discussion forums	3,00	4,00	3,42	3,44	3,53
6. Games	2,82	3,22	3,34	3,25	3,56
7. Chats	3,55	3,74	3,99	3,36	3,49
8. Ability to build dictionaries of terms	2,92	3,31	3,41	3,43	3,56
9. Document sharing	3,56	3,54	3,90	2,80	3,43
10. Tests (Quizzes)	3,44	3,92	3,80	3,32	3,48
11. Oral e-passes	3,29	3,84	3,82	3,50	3,52
12. Virtual gradebook	3,31	3,79	3,66	3,55	3,52
13. Helpdesk – platform help instructions	3,15	3,40	3,33	2,83	3,46

[b] on a scale of 2 to 5, where 2 was the lowest rating and 5 was the highest

Respondents were asked to rate the features available on the platforms (on a scale of 2 to 5, where 2 was the lowest rating and 5 the highest). Respondents using the Blackboard UltraLearn platform rated the highest the ability to discuss on forums (4.00), Quizzes (3.92) and the ability to complete oral tests using the video interface (3.84), virtual gradebook of learning progress (3.79), posting teaching materials (scripts, presentations) (3.76) and chats (3.74). In the case of the Microsoft Teams platform, the respondents appreciated the option to post teaching materials (scripts, presentations) (4.09), chats (3.99), the option for lecturers to enter information (3.93) and share documents (3.90), the option to conduct oral tests using the video interface (3.82) and quizzes (3.80). Another Moodle platform was appreciated by the respondents for a virtual gradebook of learning progress (3.55), the ability to build dictionaries of terms (3.43) and discussion forums (3.44). On the other hand, the Google Classroom platform was appreciated by the respondents for the option to share documents (3.56), chats (3.55) and Quizzes (3.44). Using the Zoom platform, they appreciated it for chats (3.46), Quizzes (3.30) and the feature allowing to upload teaching materials (scripts, presentations) (3.24).

The results suggest that users favour platforms providing integrated remote work environments (such as Blackboard UltraLearn) over those solely offering synchronous tools (like Zoom).

Table 5. Evaluation by the respondents of the functionality of selected platforms ($\bar{\chi}_\omega$ value).

	Google Classroom [b]	Blackboard UltraLearn [b]	Teams [b]	Moodle [b]	Zoom [b]
Items					
1. Chat	3,37	3,74	4,02	3,33	3,47
2. Uploading documents	3,61	3,76	4,00	3,59	3,43
3. Discussion	3,28	3,78	3,89	3,60	3,41
4. Recording	3,27	3,43	3,86	3,33	3,43
5. Background effect settings	2,91	3,09	3,79	2,00	3,40
6. Screen sharing	3,07	3,50	3,80	2,00	3,55
7. Participant reactions	3,47	3,87	3,94	3,00	3,44
8. Meetings scheduling	3,43	3,42	3,80	2,00	3,45
9. Dividing meetings into rooms	3,50	3,36	3,73	3,00	3,40
10. Adding members to the meeting	3,33	3,65	3,77	4,00	3,71
11. Giving control during a meeting	2,92	3,38	3,78	3,00	3,35

[b] on a scale of 2 to 5, where 2 was the lowest rating and 5 was the highest

In the next stage of the study, respondents were asked to assess the functionality of the platforms (on a scale of 2 to 5, where 2 meant the lowest rating and 5 the highest). Users of the Blackboard UltraLearn platform rated the highest the discussion (3.78), sending documents (3.76) and chats (3.74). For Microsoft Teams, respondents appreciated chats (4.02), uploading documents (4.00), ability for participants to react (3.94), discussing (3.89), recording (3.86), screen sharing (3.80), scheduling meetings (3.80), setting background effects (3.79), giving control during a meeting (3.78), adding meeting members (3.77), and dividing into rooms (3.73). The Moodle platform was appreciated by the respondents for discussion (3.60) and sending documents (3.59). On the other hand, the Google Classroom platform was appreciated by the respondents for the ability to send documents (3.61), divide meetings into rooms (3.50) and the user reaction feature (3.47). Using the Zoom platform, they appreciated it for adding members to a meeting (3.71), screen sharing (3.55) and chats (3.47).

Respondents indicate a preference for platforms offering a wide range of capabilities that facilitate direct interaction.

Table 6. Evaluation by the respondents of the technical capabilities of selected educational platforms ($\bar{\chi}_\omega$ value).

	Google Classroom [b]	Blackboard UltraLearn [b]	Teams [b]	Moodle [b]	Zoom [b]
Item					
1. Transparency of functions	3,52	3,53	3,82	3,07	3,32
2. Image quality	3,67	3,60	3,80	3,19	3,46
3. Sound quality	3,52	3,49	3,85	3,00	3,43
4. Intuitive operation	3,43	3,44	3,76	2,89	3,24
5. Processing/merging speed	3,33	3,35	3,69	3,11	3,26
6. Safety of use	3,19	3,37	3,69	3,00	3,24

[b] on a scale of 2 to 5, where 2 was the lowest rating and 5 was the highest

The last stage of the study was the respondents' assessment of the technical capabilities of the platforms used (on a scale of 2 to 5, where 2 meant the lowest rating and 5 the highest). The Teams platform received the highest marks for both sound quality (3.85), clarity of functions (3.82), image quality (3.80), intuitive use (3.76), connection speed (3.69) and safety of use (3.69). Nevertheless, users of each platform emphasised its technical advantages. Users of the Blackboard UltraLearn platform rated the highest image quality (3.60), clarity of functions (3.53) and sound quality (3.49). In the case of the Microsoft Teams platform, respondents appreciated the sound quality (3.85), the clarity of functions (3.82) and the image quality (3.80). The Moodle platform was appreciated by the respondents for image quality (3.19), connection speed (3.11) and clarity of functions (3.07). On the other hand, the Google Classroom platform was appreciated by the respondents for image quality (3.67), clarity of functions (3.52) and sound quality (3.52). Using the Zoom platform, they appreciated it for the image quality (3.46) and sound quality (3.43).

The results suggest that users of educational platforms value technical functionalities that support smooth and responsive communication.

CONCLUSIONS

In conclusion, unexpected events are an inevitable part of human life. The future is always marked by uncertainty. The emergence of the Covid-19 virus resulted in the Universities reaching for unknown tools. Although remote education enthusiasts have been promoting digital teaching solutions for many years, they have not gained a large group of supporters. Despite daily use of digital tools, lecturers and students primarily relied on traditional, in-person classroom formats within the university setting. However, the COVID-19 pandemic necessitated an abrupt transition to online platform courses. This shift compelled both lecturers and students to acquire new digital teaching and learning skills. Nearly three years of such experience allow us to conduct analyses of the experience gained. The results presented in this article represent the students' point of view.

The collected data allow us to conclude that students connect to the Internet many times a day or a week to learn. At the same time, they more often choose generally available communication tools, such as public messaging applications, group messaging applications and email. LMS platforms dedicated to learning are used by a small group of students, which depends on the status of the university, the level of education and the mode of education. Non-public universities, first-cycle students and part-time students use the remote formula more often. Respondents identified the most frequently used e-learning platforms as digital replicas of traditional classroom formats. This suggests a direct transfer of familiar teaching methods to the online environment. Students expressed a preference for integrated platforms that combine synchronous and asynchronous activities, offering a wide range of functionality and technical capabilities. While communication platforms are widely used, they are less valued than Learning Management Systems (LMS) by students.

The future of digitalization in higher education is largely contingent upon legislative frameworks and university leadership. The acceleration of digital education has become a fact. However, how the gained experience will be used depends on people. The Covid-19 virus pandemic, becoming a catalyst for change, resulted in the recalibration of the

organisational, didactic and scientific structure of the University, introducing it to the digital world. Universities have changed from an observer of changes to their integral participants. To conclude, leveraging students' acquired experience, skills, and enthusiasm for technology should be the cornerstone for future changes in university didactics, including curriculum and teaching methodologies. This involves adapting, adopting, and actively integrating technology within the academic environment. The goal is to introduce students to digital technologies during their formal education to prepare them for a future increasingly reliant on these tools in the socioeconomic landscape.

SUMMARY

The digitisation of higher education brought about by the Covid-19 pandemic, implemented at universities resulted in a paradigm shift from teaching from ex-cathedral to remote learning supported by digital communication systems and tools. The university walls have been largely replaced with virtual space. The rapid shift to remote learning necessitated by the spectrum of communication tools has led to a reimagining of teaching methodologies, demonstrating that equivalent learning outcomes can be achieved through alternative approaches. Almost the entire academic community has learned a valuable lesson from new technologies. As primary beneficiaries of these changes, students recognise both the strengths and limitations of digital solutions. They advocate for a university transformation that prioritises the accessibility and flexibility offered by remote learning formats. This shift should replace traditional, passive learning with collaborative, interactive, and inclusive learning models facilitated by LMS platforms. The challenges that the modern world poses to the young generation require creative thinking, creating new solutions, social coexistence in decision-making responsibility for sustainable development. Such a new reality requires a new approach to learning and teaching.

The collected research material indicates that with the development of technology and its adoption in didactic processes, universities will increasingly use remote learning, and LMS platforms are an important element of this process. Functional LMS solutions will be increasingly used to conduct entire online study programmes, not just individual subjects, especially in fields of study with fewer experimental classes that require direct contact between the student and the teacher. Such study programmes will not only feature online lectures, but will also incorporate applications and tools such as online discussions, video conferencing, and virtual whiteboards to allow students to interact with faculty and fellow students.

We live in a digital age where technology offers unprecedented access to information and experiences, expanding our world at our fingertips. Technology is ubiquitous. Therefore, it would be more strategic to integrate technology into the educational process rather than cling to outdated procedures and teaching methods. What was good in the past just can't keep up with the changes. Universities must proactively prepare for emerging trends, such as the integration of AI in education and research, given its rapid adoption across various industries (Dias et al., 2023; Prieto-Gutierrez et al., 2023; Kaczorowska-Spychalska et al., 2024). According to the authors, many scenarios for the development of higher education are possible in the future. The future may bring a hybrid education model combining traditional

and digital learning in varying proportions. A full transition to exclusively digital education is also a possibility. The extent of this transformation hinges on the academic community's ability to accommodate, absorb, adapt, accept and activate (5A) new technologies.

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INTRA-NORMATIVITIES IN TECHNOLOGIZING OLD AGE CARE WORK: MOBILE RECORD-KEEPING, REMOTE HOMECARE AND SOCIAL MEDIA USE SHAPING GOOD CARE

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Abstract: *Western societies tend to implement new technologies to old age care work to replace routines in order to make services more efficient and transparent as the population ages and public resources diminish. However, we have not paid enough attention to how care practitioners perceive their changed circumstances in old age care work. Drawing on the thematic interviews of 31 care practitioners in Finland, we analyzed how the emergence of mobile record-keeping during homecare visits, use of video visits in remote homecare and social media use in intensive service housing shaped what is perceived as good care. Leaning on empirical ethics of care approach we found that each old age care service context and its technology shape its own intra-normativities. Each intra-normativity brings different values into being in old age care, which impact on work practices and how the relations between care practitioners and clients, and with the wider public are enacted.*

Keywords: *old age care work, ethics of care, socio-materialism, technologization, intra-normativity.*

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INTRODUCTION

Western societies are currently facing a care crisis because of an aging population structure and diminishing public resources. As aging significantly increases the use of social and health care services in societies, politicians are searching for means to make old age care services more efficient (Kröger, 2019). The current political and academic remedies for the care crisis, particularly in Northern countries, are mainly technological in nature. They suggest digitalization, technological efficiency, surveillance, and AI-based algorithms as solutions to the care crisis. This reduces the phenomena to an economic and technological problem (Kovalainen, 2021). However, previous case studies of care work (Bergschöld, 2018; Ertner, 2019; Tufte, 2013; Hyysalo, 2004; Frennert & Östlund, 2018) have shown that efficiency is not easily achieved by implementing new technologies. The use and implementation of technologies in care work has created new tasks for care practitioners who are already strained (Kröger, Aerschot, Puthenparambil, 2018). Furthermore, the standardized logic of organizing work tasks guided by enterprise resource planning systems in each care practitioner's mobile phone has been seen as contradicting the situational logic of reacting to each client's individual and unique needs (Eskelinen, 2017).

Low-paid care practitioners are often excluded from technology implementation decisions but remain involved in the utilization network, which make their client relationships more technology mediated (Hyysalo, 2004). The introduction of technology in care contexts has raised worries about altering care practitioners' occupational identity (Ajslev, Højbjerg, Andersen, M., Andersen, L., & Poulsen, 2019). Core care values, including responsiveness and engagement with clients' needs, emphasized by care ethicists (Waerness, 1984; Tronto, 1993), might be reshaped by technology integration, impacting care practitioners' subjectivity (Halford, Obstfelder, & Lotherington, 2010). Research has highlighted concerns related to technology use in the context of caring for vulnerable older individuals (Hämäläinen 2020; Frennert 2023; Persson, Redmalm, & Iversen, 2022). The impact of technology on essential aspects of care, such as the professional–client relationship, physical presence, and empathetic engagement (Hämäläinen 2020), has not been extensively and empirically explored.

In our study, we lean on the research approach of *empirical ethics of care* (Mol, Moser, & Pols, 2010; Pols, 2015), which enables us to analyze how care practitioners actually shape goodness in their daily work and form new intra-normativities within care practice. It challenges care ethicists' understanding of care in its idealistic form (e.g., Tronto, 1993; Fineman, 2004; Gilligan, 1982) and unfolds care as socio-materialistic activity confined and enhanced by variety of contextual, technological, and social relations in which care is enacted. Performing good work is not necessarily the same as giving good care, thus we focus on finding variations in care practices in the care practitioners' talk, depending on how the care was organized and what kind of technologies were in use. As older adults' capabilities and work contexts vary in different old age care services, the conditions for providing good and empathic care to the clients might differ significantly. To be able to understand the variety of technological contexts we focus particularly on how mobile record-keeping in homecare, video appointments via remote homecare, and the use of social media as part of care work in intensive service housing (ISH) shape how the care practitioners consider their practices aiming at good care. The following research question lead our

empirical research: *How the technologies mentioned above shape care practices in such a way that they form intra-normativities what is considered good care from the care practitioners' perspectives?* For providing a solid theoretical point of departure, we explain in the next section the difference between care ethicists' and socio-materialistic approaches in understanding good care.

Good Care: From Care Ethics to Empirical Ethics of Care

According to care ethics theorists (e.g., Tronto, 1993; Fineman, 2004; Gilligan, 1982) caring is a social practice involving one subject encountering another and responding to their needs and abilities. Caring refers to reproductive labor that fulfills the needs necessary for individual survival, development, and social reproduction (Engster, 2005, p.51). Care ethics theorists also claim that caring aims to transform social relations by preventing dependency or force from distorting them, through three virtues: attentiveness, responsiveness, and respect (Noddings, 2013). According to Carol Gilligan (1982), being attentive in care means that everyone should have a voice and should be respectfully listened to and carefully heard on their own terms. Good care involves responsiveness, which refers to engaging in some form of dialogue with the client in order to discern their needs and monitor their responses to care (Engster, 2005). Responsiveness to a need may relieve suffering and pain, so that the care recipient may live their life as well as possible and function as well as possible in society. Respect as a virtue of caring derives from not treating clients as lesser beings because they have needs, they cannot meet themselves (Engster, 2005, p.55).

Care ethicists see the relational interdependence of people as a source of wellbeing (Pols, 2015). The idea of relational care challenges the prevailing principles of medical ethics, which is dominated by the idea of patient autonomy: the patient is a subject who exists and acts all by themselves (Kohlen, 2009). Seeing care as relational seems to be a cornerstone of old age care philosophies. For example, in person-centered dementia care, memory loss among older adults is not merely treated as a disease; strengthening the client's social contacts and their belonging to society has been particularly valued as a way of helping them maintain their identity and self for as long as possible (Fazio, Pace, Flinner, & Kallmyer, 2018). Personhood is dependent on other people, so finding ways to maintain selfhood through interactions and conversations is seen as fundamental in caring for people with dementia.

Care ethicists see empathy being at the center of good care. They consider empathy as a relational phenomenon, instead of reducing it to a personal quality, trait or capacity that can be individually measured and learned. The relationality of empathy means that it is seen as a co-creative practice involving the participation of both the care practitioner and the care receiver (Van Dijke, van Nistelrooij, Bos, & Duyndam, 2020). Empathy has been defined as a unique way of connecting with others and being able to feel the same emotions as another person, which is essential for motivation to care and for moral reflection (Slote, 2007; Hamington, 2017; Meyers, 1994). It is fundamentally other-directed, thus from the care practitioner's perspective, it requires allowing oneself to be affected by the care recipient, by listening more than asking, allowing the care recipient to lead them (Noddings, 2013).

However, old age care circumstances are rapidly changing, and technologies are transforming care relationships, and thus the normative definition of care ethics what good

care is about, has been considered too rigid and static by the research approach of *empirical ethics of care* (Mol et al., 2010; Pols, 2015). The problem of defining virtues of attentiveness, responsiveness, and respect as criteria for good care is that they are normative, and position care practices in a world of facts, with moral values added from the outside (Pols, 2015). Empirical ethics of care as a socio-material research approach defines care as the task of arranging, modulating, and resolving social bonds. Ethics comes not only from outside care, but also from within care practices, placing *intra-normativity* at the center of analyses. It is based on the relationality of things such as technologies, activities, and words, constructing relations between people. The empirical ethics of care does not suggest that the intra-normativities in care practices are necessarily good but sees them as practices in concrete historical situations that can be compared and questioned, even learnt from (Pols, 2015.) Good care can be empirically researched by analyzing how care practitioners strive in local and material circumstances to deliver good care as interrelational achievement of people. Normativity appears thus in different old age care services in different forms, when care practitioners' attempt to put something good into practice. Each practice embeds a different notion of what is good care (Pols, 2015), therefore values, that are brought into being, can be identified from the concrete situational care practice and its explanation.

Related Research: Old Age Care as Socio-Material Practice

Based on the socio-material approach to care, Annemarie Mol, Igunn Moser and Jeanette Pols (2010) have argued that care practitioners and technologies entail each other in practice. Technologies do not work or fail in of themselves, instead they depend on care work and on the practitioners' willingness to adapt their tools, but also adapt their care to the tools, endlessly tinkering (Mol et al., 2010). Here we highlight the findings of socio-material studies, which have been focused to practices of care practitioners in homecare, remote homecare, and intensive service housing. The technologies used differ and the capabilities of older adults vary in different old age care services, and this shapes care practices.

A dominating technology in homecare visits during the last decade in Finland has been electronic patient records on the clients' state of health, which the care practitioner must enter on their mobile device, as well as enterprise resource planning systems that optimize the time spent with each client. Mobile record-keeping has become the practice during daily homecare visits. It is expected to reduce errors and improve coordination between professionals (Hämäläinen & Hirvonen, 2020). However, it has been experienced to distract the attention of the care practitioners when they interact with the clients (Hämäläinen, 2022; Koskela, Känsälä & Saari, 2023). In previous studies, particularly temporal structuring embedded in enterprise resource planning systems, appearing as optimized homecare visits, have been observed to limit the care practitioner's flexibility when encountering the various situational needs of their clients. This has been resulting as neglection of the emotional dimensions of care (Dyck & England, 2012; Tufte, 2013), or even change how care practitioners experience themselves as competent professionals, considering skillful timesaving as a modern competence in caring (Bergshöld, 2018). The practice-based study of Finnish homecare practitioners (Koskela et al., 2023) analyzed the practices of balancing good care and the time-saving logic of the mobile technology. Five different strategies for combining mobile documenting and good care were found: 1) multitasking, 2) pausing interaction with the

client, 3) recording without the client noticing, 4) double recording using a memo or a piece of paper, and 5) moving the recording task outside the client visit. Balancing good care and scheduled visits was described as a tension and was managed during the work shift by 1) being flexible with client visiting times, 2) limiting tasks or speeding up work, 3) moving tasks outside normal working hours, and 4) self-regulating time-related experiences and emotions.

Introducing telecare devices, such as home-based video-conferencing tablets, has been often justified by efficiency gains, as tasks are delegated from care practitioners to clients and aging-in-place is enabled (Pols, 2010; Mort, Finch, & May, 2009). Telecare technology has been observed to shift the responsibility of health monitoring to the patients and altering the care dynamics by establishing a physical distance in a care relationship that previously involved direct physical touch (Oudshoorn, 2012; Cartwright, 2000). From the socio-material perspective, telecare technologies have not been seen as universally good or bad solutions, but rather as situated solutions, depending on the installation practices, the context of the users and care relations (Mort et al. 2009; Sánchez-Criado, López, Roberts, & Domènech, 2014). However, in terms of experiencing empathy and ethics as an essential part of care, telecare has been coercive: Older people have been monitored by devices at home, and their opportunities for residential care or physical homecare have diminished (Mort, Roberts & Callén, 2013).

Care activities in ISH consist of body work, involving direct contact with the body of the client: touching, lifting, washing them, and so on. As well as being responsible for using assistive technologies to help move residents from beds to communal areas, for example, care practitioners are responsible for arranging meaningful social activities for the residents (Theurer et al., 2015). The newest technology in use in old age care is social media (Rantala, Taipale, Oinas, & Karhinen, 2022), such as Twitter, YouTube or Facebook, either as an inspiration for social events or for documenting daily events for the public. We wanted to delve into effects of this newest layer of technology, because as far as we know, the use of social media as part of old age care work has not yet been qualitatively studied (Levonius & Sivunen, 2024). However, Nordic local authorities have harnessed social media to connect with citizens and stakeholders, enhancing transparency, accountability, and trust (Xu, 2020). Twitter (from 2023 Twitter is called X) is a prominent platform for sharing work-related content (Van Zoonen, Verhoeven, & Vliegenthart, 2016), influencing the professional identities of those practicing "working out loud" (Sergi & Bonneau, 2016). This is particularly relevant in the context of care work, in which the blending of conventional face-to-face interactions and modern online engagement shapes a diverse and dynamic professional identity (Levonius & Sivunen, 2024).

DATA AND METHOD

The analysis is qualitative multiple case study, in which the formation of intra-normativities in old age care work are interpreted in their socio-material contexts. It aims to understand how good care can be enacted and ensured, as each old age care work context has different relationships with the prevailing technology. It focuses on how mobile record-keeping in homecare, video

visits in remote homecare and the use of social media as part of care work in ISH form new intra-normativities what is considered good care.

The analysis was based on a dataset of audio-recorded and transcribed interviews, conducted in Finland, in two municipal organizations that provided homecare and two private organizations that provided around-the-clock service housing, ISH. The interviews were conducted between January and June 2021. Ten supervisors or managers were interviewed from ISH and seven from the homecare units. These interviews were used as material to describe the work contexts of the different services. The analysis of the care practitioners' experiences was based on 12 interviews in homecare, five interviews in remote homecare, and 14 interviews in ISH. Of the 31 care practitioners interviewed, 24 were practical nurses and 7 were nurses. The care practitioners were interviewed near their own work premises and the supervisors and managers were interviewed via Teams. All the interviews lasted between 60 and 80 minutes. The interviews were conducted in pairs, so that the first author participated in all the interviews and the rest of the authors each participated in the interviews in one particular research site.

The study was conducted in accordance with good ethical research norms. The research plan and data collection procedures were approved by the Ethics Committee of Finnish Institute of Occupational Health (October 9th, 2020), and all the participating organizations gave their permission for the research to be conducted. Informed, written consent was obtained from all the interviewees, who were advised that they could withdraw this consent at any point during the study. All names and other details that could enable identification of the participants were removed or altered in the text and data excerpts. We selected the interviewees from voluntary persons, taking care to include care practitioners with both little and expansive work experience, varying degrees of familiarity with using technology, and different educational backgrounds (practical nurses and nurses) in the sample.

The interview themes included descriptions of work history, changes at work and technology-mediated communication, use of social media, technological knowhow and agency, relationships with clients, understanding empathy and good care, well-being at work, and future work prospects. In this article, we focus on analyzing the empathy and good care theme, and its relation to other themes of the interviews.

The first phase of the empirical analysis was inductive and was conducted as pair work. The second and third author first coded the homecare and remote homecare interview texts into four categories: 1. Expression of empathy or empathic practice in care work: These texts discussed routines and habits, and the ways in which the care practitioners aimed at good care in their work. 2. Good care: These texts discussed the definition of good care, caring, and empathy. 3. Significance of care: These texts discussed the importance of empathy in care work. 4. Being able to experience empathy in everyday work: These texts discussed the factors that promoted or hindered feeling empathy and forming empathic relationships with clients. Using the same categories, the first and the fourth author then coded the interview data from the ISH. In the first coding phase the Atlas.ti program was used.

The first category (expression of empathy or empathic practice in care work) became the largest, and the content of its excerpts was the richest and most diverse. Therefore, we selected it for deeper analysis. Five categories were then constructed from these excerpts which reflected the social circumstances and habits of enacting and creating good care: 1. Creating circumstances for empathy, 2. Sharing emotions and touching clients gently, 3.

Encountering clients as human beings, 4. Learning from the client, and 5. Promoting social inclusion and a good life.

After the content analysis, based on categorization and splitting the data into small analysis units, the first author read the interviews as entire texts, one service context at a time. This second phase of the analysis was the contextual narrative analysis (Denzin, 1997, p. 231–249), in which the story of each interview in its old age care context was interpreted. The findings were partly written based on the preliminary categorization, and partly as a way to help us understand how the socio-material context and use of technology shaped good care. We focused on how the care practitioners' relationships with technologies and clients constructed their practices of good care in the interview narratives, thus resulting as identifying typical intra-normativities in each old age care context. For the analysis of the intra-normativity, we interpreted the values that were brought into being in the context- and technology specific care practices, which the care practitioners had described in the interviews. This interpretation phase was inspired by Jeanette Pols (2015, p.87) empirical ethics analysis

RESULTS: INTRA-NORMATIVITIES IN OLD AGE CARE WORK

The findings show how the socio-material context, and the use of different technologies shape the care practices and care practitioners' striving for the good care. We begin by describing each old age care context, and then continue with the results of the care practitioners' interview analysis.

Homecare as a Care Context

In recent years in Finland, social policy has aimed to reduce the proportion of institutionalized care and increase the proportion of homecare of older people. The staffing of homecare has not been sufficient, and the working conditions of homecare workers have deteriorated, as the number of homecare clients and the complexity of their health problems have increased (Kröger et al. 2018). Homecare services in Finland are a combination of home help services and home nursing, but in last years they have become more medical, and care focused (Ruotsalainen, Jantunen, & Sinervo, 2020.).

In municipal homecare, the practical nurse usually makes 8–12 client visits during the work shift, whereas during the evening shift and the weekends they may make up to 15 client visits. For the practical nurse, work at the clients' homes currently makes up 60% of their working hours, and their rest of the time is spent in transit between clients' homes and working in the office. Nurses usually make 2-4 client visits during the work shift, and the rest of the time they work in the office. The greatest problem in organizing work from the client's perspective is that care practitioners (nurses and practical nurses) constantly change, possibly resulting in up to 200 different care practitioners for a client over two years.

Finnish wellbeing and aging policy has primarily prioritized older individuals' autonomy and self-care, leading to rapid adoption of home-based welfare technologies (Kröger, 2019). Over the past decade homecare work has become increasingly technologized as, for example, various data systems and communication applications have been implemented in homecare

workers' daily routines. Simultaneously, older peoples' homes have turned into technological environments, meaning that the care workers also must take care of the functionality of the clients' technologies and guide their clients in their use. One of the main technologies affecting the daily organization of homecare work is an enterprise resource-planning (ERP) application on the homecare practitioners' mobile phones. This system is for supervisors to allocate homecare visits among the team, and then monitor them in real time. It functions in parallel with the patient record system and service planning system.

Intra-Normativities Triggered by Mobile Record-Keeping in Homecare

Homecare practitioners use their mobile phones at least two ways during the work shifts. The ERP application provides them with a scheduling and organizing tool as the system shows the client visits, their estimated lengths and the task lists. The homecare practitioner also uses the mobile phone to document the tasks and the health state of the client during the visit to the patient record system. The ERP shapes the work of the care practitioner and care as something which should be done within a time-limit, which creates sometimes difficulties in keeping up the planned schedule. *Being present with the client and facing them calmly regardless of the care practitioner' emotion that they are in a hurry, appears to be an intra-normativity* deriving from this situation. Rushing and time limits are pushed away from the care practitioner's mind, as one described:

> *When you're given a certain amount of time to be in their home, it's a rush somehow, like that, but as long as you don't show it to the client and you're calm, even though you know you're in a terrible hurry to do something, but still you are here and do everything calmly right to the end and, well...//...How can I explain? Just do things calmly. Even though I know I have to run afterwards, I don't think about it, I'm with the client for the moment, or I give them time and even sit and talk, not about work-related things. Then I give them the time if they want to talk or want someone to be present. It's important that someone is present and talks. So, I still take the time, even though I know I could just do my work and leave, but I still take the time to... It's just that, again, I'm not really... I don't look like I have to go somewhere else. (I44)*

However, care practitioners may experience portraying that they are not in a hurry as ethically strenuous (see Nikunlaakso et al., 2019). As was expressed in the excerpt: "Even though I'll have to run afterwards, I don't think about it, I'm with the client in that moment". They have to combine two contradicting demands of care work – being efficient and following the scheduled rhythm of visits and concentrating on each clients' needs and circumstances.

Other types of intra-normativities derive from the duty to document client data during the home visit. *An intra-normativity, which was common to the majority of the care practitioners was that they avoid looking at their mobile phones during their visits, in order to focus on interaction with the client.* "If I look at my phone all the time, the client may feel insecure" (I8), as one interviewee put it. As an earlier analysis (Koskela et al., 2023) on mobile documenting practice showed, care practitioners tend to develop several strategies to hide mobile record-keeping from the client, such as documenting without client noticing, using paper and pen instead of the mobile phone, or moving the documenting task outside the client

visit. This kind of avoidance of using mobile phone in the front of the client makes the care practitioners to orient themselves by reading in advance on their mobile phones who they are going to visit and what needs to be done. As an interviewee described:

> *But if, like, all this medicine stuff, even in [the name of the patient record system] was okay, yeah, you wouldn't be fidgeting and twiddling with your phone so much. That's why I've got into the stupid habit of reading the care plan before I start, because it's really embarrassing for me to go to a client's house and have my hand on my phone like this. Then I already know what I'm going to do and I can look the person in the eye and talk to them at the same time. (I49)*

As described in the excerpt, all kinds of changes in the ICT system, for example, having to find medication in the patient record system on their mobile phone during the visit was perceived as embarrassing because it would disturb the face-to-face contact. Therefore, fidgeting with the mobile phone was preferred to take place outside the client visit as much as possible.

Another kind of intra-normativity can be identified from the cases when the care practitioner multitasks with mobile documenting and a caring task. In these cases, the mobile documenting was explained to take place simultaneously with a caring action, as an interviewee described: “I put on the soundtrack of some popular music, rub the client from their shoulder while writing with one hand to the mobile phone.” (I45) *We can name this kind of intra-normativity as redeeming the use of technology with good deeds.*

In case the mobile documenting requires taking place right after for example medicine intake of the client, the care practitioner may justify it by apologizing from the client for being forced to focus on mobile documenting for a while, as an interviewee put it:

> *And then all those medicine administration records, they are so accurate, when you have to read every medicine there, really read there, so I am not really able to talk the same way as before. I might sometimes notice that I've been quiet for a long time, and then I just say to the client that I'm sorry that I have to write here, that's why I'm quiet. (I47)*

Although the care practitioners did not report any complaints from the clients for pausing the interaction, they tend to ask a permission for mobile record-keeping from the clients, as an interviewee explained: “I always say that, now I am documenting. They usually reply: Indeed, do so in peace.” (I47) Although the clients, who have been a long time as clients in homecare, are used to mobile documenting, *permission-asking or apologizing for using the technology by the care practitioner appears to be a typical intra-normativity*.

To summarize, these four kinds of intra-normativities of pretending not to be in a hurry, avoiding the technology use in front of the client, asking permission or apologizing it, or even redeeming the use of the technology by good deeds, reflect the value of prioritizing the human encounter and interaction, and not focusing to technology use when the client is present. However, the interviews of the care practitioners who made physical homecare visits revealed how planned schedules, embedded in ERP, and the mobile record-keeping obligation during the visits distracts the care practitioner’s attention from forming empathic relationships with the clients. This may cause ethical strain and a conflict between being

empathic (with time to listen to each client) and being a good worker (taking care of all the clients of the day on time, and mobile document their state during the visits).

Remote Homecare as a Care Context

Remote homecare in Finland refers to a service in which the care practitioner and the older client are in contact with each other via voice and the screen of a tablet computer (STM, 2020). In both our homecare sites, the municipality was about to increase the use of remote homecare (aiming to replace 20% of homecare visits by video visits). According to the supervisors, short home visits are replaced by video visits when clients can care for themselves and can be guided. A video visit is for making sure that the client takes their medicine, eats their meals, and does their exercises, or for when a client needs to chat for a while. The care practitioners reported that this strengthens the digital agency of the client, although the contact requires minimal technical effort by the client. The motives for remote homecare also derive from making care easier and more cost-efficient by centralizing remote homecare service: "Travel costs are saved, and a small number of care workers are able to provide care very efficiently to a bigger number of clients", as one supervisor described.

In the municipality in which we interviewed care practitioners from the remote homecare unit, typically, one or two care workers contacted 40 clients during the morning shift, and two care practitioners contacted 50 clients during the evening shift. In both our homecare research sites, the supervisors described the video visits as very positive, intensive work for the care practitioners, and as a channel for social contacts between elderly people, despite this being via a screen. The role of the care practitioners in maintaining the clients' technological tools seemed much smaller than in physical homecare work. It focused on reporting disturbances in the video technology to technical support.

Intra-Normativities in Remote Homecare with Video Visits

In remote homecare, the socio-material environment of the care practitioners is a landscape office, and they connect with clients via a screen, one call after another. Facial expressions stand out as a way of expressing emotions to the client, as physical touching is not possible. During the COVID-19 restrictions, the faces of the homecare practitioners who did physical visits were covered by masks, and thus the benefit of video visits was not having to wear masks. The care practitioner's smile was more easily seen by the clients and created a positive start to conversations, as an interviewee described:

> *I've noticed that, whether it's empathy or whatever, but I smile a lot. Sometimes I find myself smiling so much that when the call ends, my face is stiffened. Maybe a little too much sometimes. I've noticed that it's something that makes clients feel positive right away. (I4)*

Smiling through the screen can be seen as an intra-normativity that is enhanced particularly in remote homecare, because neither of the care practitioners making physical home visits mentioned the significance of smiling. Another difference in remote homecare compared to physical homecare is to be able to focus on interaction with the client during the video visit because care practitioners are not so busy helping or serving the client. The care

practitioners could not multitask during a video visit, which was experienced as making the interaction more focused and initiated a new kind of guidance talk, as one interviewee described:

> *After all, the encounter with the client is different in that you're present all the time, in a way, you're not able to do anything else at the same time, like I'm making coffee or porridge or something and sometimes I shout to the client to do this and that. That [in video visit] you're always face-to-face with the client and in a way you give all your time to them. And then of course the fact that the client has to do the things themselves, from a rehabilitative point of view. You can't help in any way, no matter how much you'd like to heat up the food for them, so it's a little easier and it doesn't take you so long. You just have to try to guide and help. (I12)*

This kind of encouragement of the client's autonomy can be named as an intra-normativity confined by the fact that the care practitioner cannot do physical caring acts in remote contact for the client. Learning and listening to what is going on in the clients' life is prioritized during a call, although the purpose of the call was defined as checking that medication was taken in time, as one care practitioner described:

> *The fact that our work is about listening to the client, even if the purpose of the call is to confirm they take their medication or that they take the medication during the call, you can't immediately, as soon as the call starts, you can't say A [name of the care practitioner] here: Just take your medication. No. You have to read the client. First, you ask, 'how are you' and then slide into the call, if the client doesn't immediately like to take their medication, sneak in the question about the medication: That is, you can't command the client to do things, otherwise they'll press the end call button. You have to be able to read the client by their gestures and speech. (I5)*

This excerpt reflects *an intra-normativity in remote care, not to be too straightforward or controlling in the client interaction*. Direct questions about medication would be experienced as rude, so the care practitioner listens to what is going on in the client's life instead and then sneaks in the question, if the care practitioners could not see via the screen the medicine intake taking place. This kind of indirectness in interaction displays respect toward the client.

Many interviewees described how reading the client via the screen is important, in order to observe whether they are lonely, sad or happy and to get to know them better in each call. The care practitioners seemed to prioritize creating empathic relations with their clients, while also maintaining their surveillance task. To nourish lively conversations with the clients, the care practitioners collected interesting topics to talk about with their clients into a notebook to share with colleagues. This kind of activity turns the attention from symptoms or pain onto the social life and life history of the client, thus strengthening the client's personhood and connectedness, as the person-centered old age care philosophies also suggest (Fazio et al., 2018). In this sense *encountering the client as a person in their life continuum, not only as a patient, can be identified as an intra-normativity* enhanced by the video visits as well.

To sum up, meeting via screens restricts remote homecare and clearly shifts the focus from simultaneous actions and talking to reading facial expressions and discussion. The care practitioner cannot gently touch or help the client physically, which is a restriction from the perspective of good care. Indirectness in determining whether the medical need has been fulfilled turns the care practitioners' attention to the clients' life in general, thus showing respect to the client. Four kinds of intra-normativities were identified triggered by the use of video visits: smiling, encouragement of the client's autonomy, not acting directly in a controlling manner, and focusing into client's life instead of symptoms in the discussion. All these formed the goodness of the remote homecare. The values brought into being through these intra-normativities refer to respecting client's autonomy and seeing the client as an agent in their own life context, which is enhanced by the fact that the care practitioner replaces their caring acts, and bodily movements by talking with the client and their interests.

Intensive Service Housing as a Care Context

In Finland, 24-hour service housing provides personalized care based on individual needs, regardless of the time. This encompasses functional capacity, meals, cleaning, and activities to promote participation and social interaction (Social Welfare Act, 2014). In ISH, care practitioners work around the clock, usually divided into morning, evening and night shifts. The facilities are often divided into group homes of 10–20 residents who need various kinds of help in moving, eating and in their existential vulnerabilities due to physical or mental impairments (Hämäläinen, 2022).

Technology use in these settings varies. In one site, technology was employed to foster social connections for older individuals, enabling video conferencing and tablet usage to engage with loved ones. This reflects a cultural shift in old age care, from passive nursing home residents to active participants integrated into society (Theurer et al. 2015). Social media has been embraced as it enhances the visibility and public perceptions of care of older adults. Sharing daily activities on social media has become part of care practitioners' roles but is still rare in general in old age care. Thus, intra-normativities, which derive from social media use and represent a new emerging work role of the care practitioners, are worth exploring.

Intra-Normativities Emerging with the Use of Social Media in ISH

Care practitioners in ISH spend their work shift moving between the private rooms of the residents and common spaces of the nursing home. Touching, hugging and verbalizing care tasks were described as forms of creating an empathic relationship with clients. A warm relationship between the care practitioner and the client may form without words, through eye contact and a gentle touch and voice. The care practitioners claimed that eye contact was an important way to communicate when they had to use facemasks during the COVID-19 pandemic. They used a significant amount of time helping the residents get up and get dressed, and taking them to eat, but there was also time for doing nice things together such as baking, singing, chair exercising, or going outdoors.

In terms of how social media use shapes care and relationships with clients, it seems that as a work task it activated care practitioners to think and even arrange more events and shared activities with the residents, as described in the following:

> *Well, probably in the way that you perhaps think more about, or come up with all kinds of events, nice things, in which the residents can easily participate and then it's nice to post Twitter photos. So, all the time you and your colleagues think what could be next, nice to do together. And the residents like it, you can really see that there's a smile on their faces. (I23)*

Social media use strengthened experiencing care as social activity, and in the interviews the care practitioners described how they posted photos on the organization's social media channels from the events, which they thought were somehow visually funny or beautiful. *This reflects an intra-normativity that social activities and their esthetics are an important part of care*. The care practitioners felt that social media use was seen as something fresh and increased their feeling of being up to date in their work. On the other hand, the purpose of using the social media was reported to show the world that old age care work could be as interesting as any other work, as expressed in the following excerpts:

> *I try to take social media into my work to show what my work is. So that it shows to the world that it isn't always washing asses, giving medicine, or moving the client from here to there. It can be normal activities, like in everyone's life. They are still people, although they are old people, they have a lot to live for. (I22)*

> *I am the one who chooses, what I think is worth immortalizing; this is the one photo I want to share with the world. (I22)*

This kind of intra-normativity is connected to a new kind of motivation to change the bad reputation of old age care by making the everyday care work transparent for their closest and the entire society, and something which the employees can be proud of. However, the care practitioners were aware that from the client's perspective the social media use does not make a difference to the elder client or improve care, as an excerpt explains:

> *For example if you think from the residents perspective, for them they are really old people and they don't really get any benefit, so either you put it on social media or don't, what activities are going on and that's the everyday thing that we're supposed to do for residents, they're getting no benefit, I think, social media is playing no role, but for organization, for advertisement purpose and for making nurses or the employers more active, it does. // personally I find it fun, especially when I have spare time so OK, let's put it that everybody knows that we are doing this, so yeah I think it depends from what side you are. (I26)*

To sum up, in ISH social media provides the care practitioner an opportunity to show loved ones and the audience the positive spirit of care of older people. Planning nice events for social media has even catalyzed activities that promote a good life (see also Levonius & Sivunen, In Press). Two kinds of intra-normativities were identified connected to social media use in care work: motivation to show social events with the clients increased seeing old age care more as a social and esthetic activity. Furthermore, postings of social media were seen as making an impact to society in seeing care of older adults in a more positive and

attractive light. From the ethical perspective, all the older people may not understand how they are an object of gaze or marketing material for the organization when their photo is posted in social media. However, this seems justified by the intention of the care practitioners to create a better reputation for care work in this era of dwindling resources for old age care and the shortage of employees. The values brough into being through these intra-normativities enhanced by the social media express that social activities are a valuable part of ISH, and old age care should be seen as a pride.

DISCUSSION

Our analysis contributes to the scarce number of qualitative studies studying use of technologies from the ethical point of view, as observed also by Hämäläinen (2020). It focused on how different technologies shape various intra-normativities in everyday old age care what is considered good care. We examined how care practitioners conceptualized their circumstances and practices for creating empathic relationships and caring about their clients in three different socio-material contexts. Although our aim was not to compare different old age care services as such, bringing them into a coherent, parallel, and contextualized analysis, help to better understand how the different technologies change the relationship between the care professional and the client, and what kinds of practical and ethical values are embedded in technology use situations.

The care practitioners in **homecare** expressed that time-bound visits and mobile documenting during home visits were the most disturbing obligations, and that they possibly challenged the sensitive encounters with clients and caused ethical strain. The intra-normativities derived from mobile technology use during client visits indicated that care practitioners tended to hide both their mobile documenting task and that fact that they were in a hurry, in order to not jeopardize the flow of interaction with the client. The practices of combining mobile documenting with good care during short home visits were various (Koskela et al., 2023), but all of them reflected that interaction with the client was valued more than the use of technology. It seemed that the care practitioner tried to keep the home visit as focused to the clients' needs as possible, as if the technological task did not bother at all, or if it did, it was a matter which should be apologized or compensated. Compared to research findings of Bergshöld (2018) and Tufte (2013) about use of similar technologies, the values of the care practitioners behind the intra-normativities in our study seem to be more human-centered, not seeing the technology turning care work as mechanical and efficient performance. On the other hand, our study is in line with the previous studies' (Bergshöld, 2018; Tufte, 2013; Hämäläinen & Hirvonen, 2020) finding that care practitioners do not only adapt to the mobile documenting, but they also create their own practices to tame it to better suit care work. Furthermore, our findings indicate that such care ethicists' virtues as attentiveness, responsiveness, and respect (Noddings, 2013), in the client encounter are still enacted although the care practitioners use mobile technology during their home care visits.

Although the entire setting of **telecare** can be seen in ethical sense problematic, as surveillance invading privacy of the clients (Mort et al., 2013), the care practitioners aim to enact good care via video appointments, shaping their own intra-normativities how to create goodness in them. In remote homecare the opportunity for good care is confined by

encountering the client via screen. Therefore, the care practitioners expressed empathy through facial expressions, such as smiling, eye contact, and words. The perceptions of the care practitioners indicated that contrary to general concern, the shift from physical homecare visits to video-mediated remote homecare does not necessarily imply a shift from human-centered care to distant and emotionally cold care. Remote homecare seemed to intensify the client–care practitioner interaction, as the technology mediation enabled the care practitioners to concentrate better on the clients' issues and lives. Whereas during homecare visits focusing on activities for a good life was rare, in remote homecare the carers and clients could at least talk about them extensively. Intra-normativities embedded in video-mediated interaction included an indirect way of approaching clients' symptoms or illness or asking about the medicine intake. The screen made it possible for the care practitioner to see if the medicine was taken during the video visit, although the conversation was flowing around other things. Previous research on telecare showed how the clients as users modify telecare for their own purposes or reject the use if it does not fit their expectations (Mort et al., 2013). Our analysis unfolded how care practitioners in remote homecare may act in empathic way and consider clients not just patients but human beings who need to be socially connected.

In **ISH**, the use of social media as part of care work displayed empathic relationships and social events in residential care under the lens of the public eye. The care practitioners even made an extra effort to arrange events for the older people, to be able to post these on social media. Social media triggered an intra-normativity of seeing old age care more as a social and esthetic activity. However, according to research on residential care, more social events do not necessarily make residents' life more meaningful if they lack opportunities for their own contribution or reciprocity (Theurer et al., 2015). If the criterion for arranging social events derives from esthetics and entertainment, triggered by the social media demand, the purpose of making the event meaningful from the client point of view may be lost. In addition, from the ethical point of view, older people may not understand social media enough and it can be difficult for them to refuse being the object of the public gaze (Levonius & Sivunen, 2024). The reconciliation of ethical principles in social media and care has not been extensively studied (Lemon & Boman, 2022), and this kind of setup is rare in any case. Therefore, more research on how the use of social media shapes care workers' practices is needed. On the other hand, social media as part of care practitioner's work provides an almost a revolutionary opportunity for presenting care work in a more positive light for the citizens as a source of wellbeing, not only as a cost for the society.

As our analysis indicated different technologies create different intra-normativities to old age care and change the understanding of what is considered good care. Although care practitioners struggle to keep the quality of old age care not to be disturbed by mobile documenting in homecare, focused conversationally on client's social connectedness and good life in remote homecare and take the opportunity to improve the image of old age care with the social media, the practice of caring may benefit from reminding of care ethicists' values of good care. Intra-normativities should be seen as relational (Pols, 2015), creating different kinds of goodness depending on from whose point of view they are looked from: client's, practitioner's or the old age care service system's. An example of a contradictory and problematic intra-normativity is the use of social media with older people to gain better image for the old age care. Presenting good care is not the same as good care.

CONCLUSION

We found and made visible how the use of mobile documenting, remote homecare via video visits and social media use in residential care shape how old age care is enacted and what is considered good care in care practitioners' daily work. The technologies in care work functioned as a channel for communication between professionals, between professionals and clients and between care community and wider public. Although we focused into one technology in each old age care context for the sake of clarity, the future of technologization of care may include the use of several technologies in every care practitioner's work. However, different intra-normativities shaped by the technologies bring different values into being. In condensed form they can be named: 1) prioritizing the human encounter and interaction over mobile record-keeping in homecare visits, 2) considering the client as an autonomous agent in their own life context, not only as a patient in remote homecare conversations, and 3) arranging social activities in old age care as a showcase, which improves the public image of old age care via social media.

One limitation of the analysis is that it was based on interviews of care practitioners and not on observations of work, or the clients' perspective. Observations of the interactions between care practitioners and clients were analysed from the perspective of good care and empathy in our previous article, showing how these intra-normativities may function in everyday care work (Saari, Koskela & Känsälä 2024). The interviews provided a point of departure for the ethnographic part of the study. Interviewees tend to mostly explain the way in which they would ideally like to act, although hindrances and excuses when the empathic relationship became obsolete in the situations were also discussed.

IMPLICATIONS FOR THE POLICY AND PRACTICE

As a whole, the care practitioners' perspectives and their intra-normativities indicate that they are able to use technologies for striving to attain good care practices, although the implementation of technologies in the political sphere has been justified with the values of cost-efficiency and coping alone of the older people rather than provision of better care (Kröger, 2019). To guarantee good old age care during the era of digitalization, the care practitioners should have enough time for creating their own digital agency and ethical understanding of the different welfare technologies. Organizing care work to support autonomous, flexible ways to act in such a way that care practitioners may find their way to use technology for responding to the clients' needs and provide good care, should be a priority as it benefits the well-being of both clients and care practitioners. Continuous reflection of care practices within work communities, and at the societal level are needed, when new technologies are implemented in old age care. The findings of research approach of empirical ethics may provide a possible point of departure for these ethical discussions and evaluations.

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A REVIEW OF CAVEATS AND FUTURE CONSIDERATIONS OF RESEARCH ON RESPONSIBLE AI ACROSS DISCIPLINES

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Abstract: *Research on responsible AI has boomed over the past few years. Yet, an understanding of the responsible AI research across primary disciplines is missing in the literature. Through a review of 1224 studies across 7 databases, a total of 177 studies were included for a review of responsible AI across the areas of Business, Engineering, Governance, Health, Science, and Social Science. Using grounded theory and axial and open coding, we extracted and summarized areas, principles, research designs, challenges, findings, and trends in responsible AI research across the emerging areas. The contribution of this work is presenting the caveats and future considerations of research on responsible AI holistically and across primary disciplines in higher education.*

Keywords: *artificial intelligence, AI, responsible AI, education, review*

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INTRODUCTION

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A healthy society advocates and enforces responsible behaviors by its citizens. Philosophers, historians, and others (e.g., Nietzsche, Sartre, Heidegger, Levinas, and Derrida) have embarked on the notion of responsibility and responsible behavior (Raffoul, 2010). Responsibility is an umbrella and all-encompassing term, but broadly it necessitates taking accountability and ownership of actions, whether they be good or bad (Gold, 2021). It predominantly stems from the philosophy of morality and humanistic growth (Constantinescu et al., 2021). Today, we see conflicts of responsible behavior not only among human citizens but also among artificial intelligence (AI) citizens who have become a part of our world (Yudkowsky, 2008). AI applications and agents, whether sparse or at scale, have come to be used by humans for collaboration and automation in decision-making. This has as a result sparked concerns on who, when, and how should be accounted responsible for actions and their subsequent implications (Giroux et al., 2022; Puaschunder, 2019). Despite the advancements in the technologies and algorithmic designs of artificial intelligence, AI is still missing a complete picture of societal values including responsibility, and may exhibit responsibly indifferent behavior (Cheng et al., 2021). There is a challenge to identify more of the must-have humanistic characteristics of AI (Ozmen Garibay et al., 2023). There is as such a need to understand and envelop responsibility in AI (Robbins, 2020). Neglecting societal needs such as responsibility and solely focusing on mathematical and algorithmic enhancements of AI programs is significantly detrimental. This approach may deter the notions of humanistic traits and have long-term and irreversible impacts on society and humans (Santoni & Mecacci, 2021). Neglecting these issues can be particularly harmful today given the proliferated uses of AI across disciplines and contexts (Sætra & Danaher, 2022).

PRIOR WORK AND GAP IN RESPONSIBLE AI

A summary of some key research on responsible AI can be seen in Table 1. Prior work has, for example, examined the precursors to responsible AI (Mikalef et al., 2022; Schiff et al., 2020), cases for responsible AI (Wang et al., 2020), explainable AI (Arrieta et al., 2020), and professional AI (Alam, 2023). Such research informs and warns of how responsible AI should be conceived and employed but may lack insight into the current state of research around responsible AI, especially across diverse areas. Much of the prior research conducted highlights the importance of responsible AI and holistic ways to address it, as presented in Table 1. Findings from such research often lead to the development of frameworks and best practices to devise AI responsibly. Yet, few prior research, particularly reviews, have examined the current state of research on responsible AI. We are motivated to examine the state of research on responsible AI across diverse disciplines. This survey is needed given that AI applications and techniques may greatly vary across different areas, leading to more distributed rather than universal notions of responsible AI behavior. Through a review of the literature, we are thus interested in examining emergent research trends on responsible AI across diverse areas and also see if similarities and differences exist. In doing so we wish to

contribute to our understanding of research on responsible AI at every step of the way and stage of research and further share challenges remaining with research on responsible AI across different areas.

Table 1. Summary of prior work

Reference	Key foci
(Akbarighatar et al., 2023)	Combined topic modeling with manual content analysis to review the literature on AI maturity and readiness.
(Alam, 2023)	Share the development of a course titled Safety, Fairness, Privacy, and Ethics of Artificial Intelligence" (SFPE-AI).
(Arrieta et al., 2020)	Present a methodology for the large-scale implementation of AI methods in real organizations with fairness, model explainability, and accountability at its center.
(Benjamins et al., 2019)	Share issues and lessons learned in an organization that develops and uses AI, both from a technical and organizational perspective.
(Cheng et al., 2021)	Provide a systematic framework of Socially Responsible AI Algorithms focused on examining the subjects of AI indifference.
(Clarke, 2019)	How organizations may manage responsibly and the need for risk assessment.
(Dignum, 2019)	Share ways in which AI can potentially produce unintended consequences and how to improve our knowledge about responsible AI.
(Mikalef et al., 2022)	Present five explanations for the principles-to-practices gap and the need for impact assessment.
(Schiff et al., 2020)	Present four themes that lead to 15 recommendations for responsible AI.
(Shneiderman, 2021)	Present a responsible AI initiative framework that encompasses five core themes for AI solution developers, healthcare professionals, and policymakers. These themes are summarized in the name SHIFT: Sustainability, Human-centeredness, Inclusiveness, Fairness, and Transparency.
(Siala & Wang, 2022)	Provide a bottom-up mapping of the current state of research at the intersection of Human-Centered AI, Ethical, and Responsible AI (HCER-AI).
(Tahaei et al., 2023)	Share 10 responsible AI cases from different industries to understand the use of responsible AI in practices

GOAL AND RESEARCH QUESTION

Rooted in a grounded theory approach, the goal of this research is to review literature across diverse domains emerging from the studies (i.e., science, engineering, governance, social views, and science) and identify research trends related to responsible artificial intelligence (AI). Grounded theory has been long used in higher education research (Conrad, 1982), enabling a differentiation between interpretivism and an absolute truth from an external reality. In recent years, research has shown that grounded theory has become one of the most commonly used qualitative research approaches (Stough & Lee, 2021) as it allows for

generating a theory that is grounded in data (Birks & Mills, 2022; Morse, 2016; Stough & Lee, 2021; Timmermans & Tavory, 2007). Using grounded theory in the review work hence offers a more structured yet interpretive approach to codification and analysis (Dunne, 2011; Wolfswinkel et al., 2013). We seek to answer the following topic and associated research questions: ***What are emergent trends in research on responsible AI across diverse domains (i.e., science, engineering, governance, social views, and science)***

1. What are the emergent principles of responsible AI?
2. What are the emergent research designs on responsible AI?
3. What are the emergent research challenges on responsible AI?
4. What are the emergent research findings on responsible AI?
5. Putting it together: What are emergent principle-research design-findings-challenges on responsible AI?

We aim to understand research designs, challenges, findings, future work, and implications surrounding responsible AI overall and across the mentioned domains. We first provide background information on responsible AI (RAI). The methods section summarizes our search process and protocol for conducting the systematic review of responsible AI in the literature. The results section summarizes our findings on how the landscape of responsible AI compares across different domains in the literature. The discussion section further synthesizes and presents the implications of research across different domains. The contribution of this work is to offer a picture of the current state and future considerations and directions for research on responsible AI across diverse areas.

METHODS

Using a grounded theory approach, we study and analyze the reviewed studies to obtain key emergent themes of research and similarities and differences across areas (Stough & Lee, 2021; Thornberg, 2012). The conceptualization of the area and its associated attributes such as study gap/motivation, context, design, findings, and so on are informed by reviewing each article and identifying what emerges. In other words, we use open coding to codify emergent topics from the reviewed studies. Wherever possible, we then apply axial coding to thematize and classify the attributes or summarize them in a few constituting words.

SEARCH PROCESS

An overview of our search process is presented in the PRISMA chart in Figure 1. We searched the string: "responsible artificial intelligence" or "responsible AI" in the following databases: PubMed, JSTOR, SCOPUS, IEEE Xplore, Science Direct, Semantic Scholar, Web of Science, and EBSCOhost. We then uploaded the articles to the Covidence software. Covidence is an online tool used for carrying out a systematic search process. It helps with identifying duplicates and organizing the search process. Of the total of 1224 publications uploaded, a total of 460 duplicates were removed from Covidence. Since we were interested in articles that put responsible AI at the foci of their work, we only selected articles from each database having "responsible AI" incorporated into their title and abstract and which were peer-reviewed and disseminated in English.

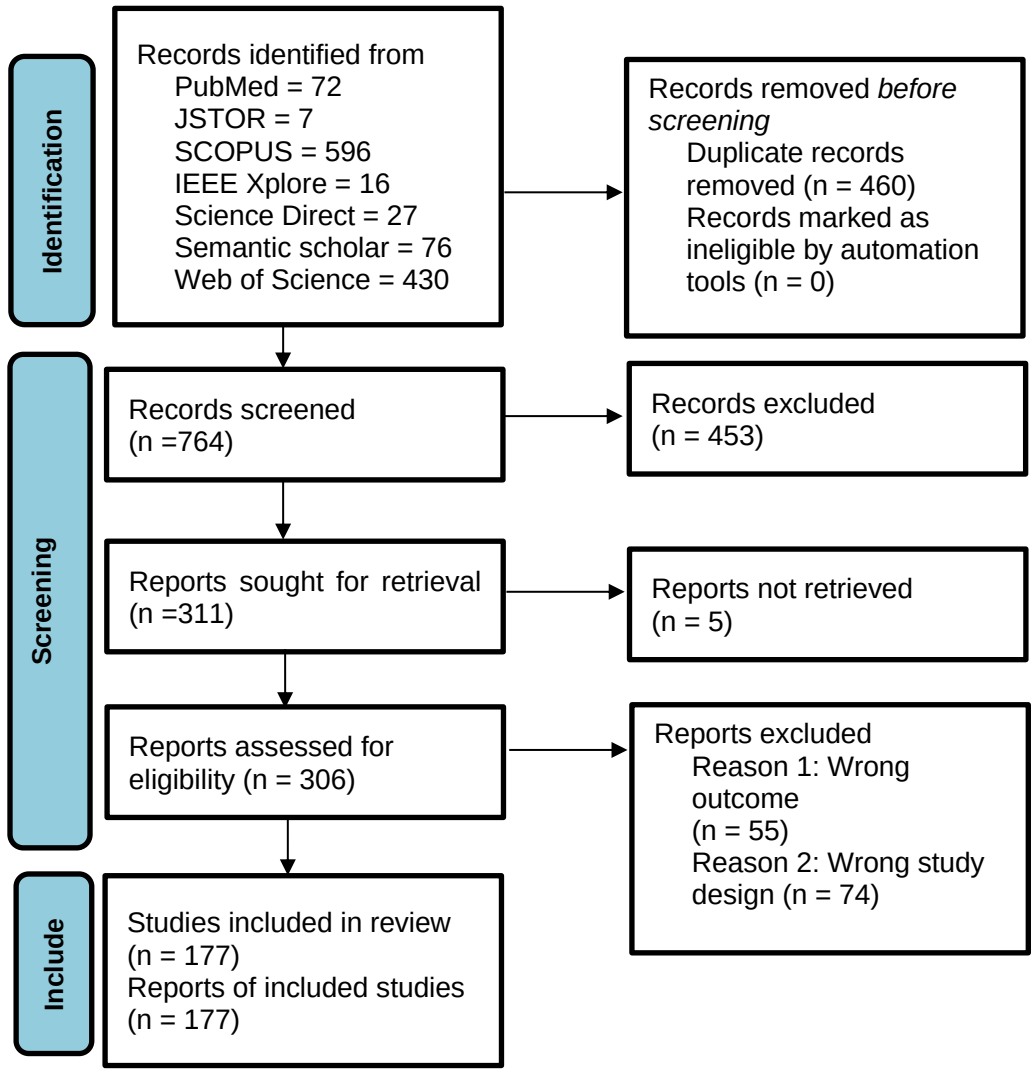

Figure 1. PRISMA Chart

METHODOLOGICAL FRAMEWORK

Our work is rooted in the grounded theory approach, where the coding and thematic analysis of research informs the findings of our research questions. This also meant that we depended on the literature reviewed to identify areas of interest. After undergoing the review process shown in the PRISMA chart in Figure 1. We used the title and keywords of the reviewed studies to attribute their primary area/discipline. A summary of the areas extracted and references can be found in Table 2. After review and thematic analysis of 177 studies included in this review, a total of six areas emerged, namely:

- Business (*N*= 12, 7%): including finance, and fintech.

- Engineering (*N*= 20, 11%): including the application of engineering across disciplines other than health.
- Governance (*N*= 12, 7%): including law, policymaking, and law enforcement.
- Health (*N*= 36, 20%): including medical and biomedical applications.
- Science (*N*= 42, 24%): including data science and pure sciences.
- Social science (*N*= 55, 31%): including perspectives, panel discussions, and practices in teaching and learning.

As can also be seen in Table 2, the highest number of publications were in social science, followed by science, health, and engineering, and the two areas of business and governance the least. The emergent keywords also show to be variable across the areas.

Table 2. Areas and references of reviewed studies

REFERENCE	AREA (% OF TOTAL)
(Asif et al., 2023; Crockett et al., 2023; Fenwick et al., 2018; Ferreira et al., 2023; Hadley, 2022; Haidar, 2024; Maki et al., 2023; Marcoux & Martineau, 2022; Maree et al., 2020; Narayanan, 2023; Papagiannidis et al., 2022; Wach et al., 2023)	Business, *N*= 12 (7)
(Abeywickrama et al., 2019; Alfrink et al., 2023; Bao et al., 2023; De Brito Duarte, 2023; Delecraz et al., 2022; Dominique et al., 2023; Falco, 2019; Faßbender, 2021; Gavrilova, 2023; Hu, 2023; Kamada, 2016; Kuck, 2023; Lee et al., 2024; Lescano et al., 2023; Lewis et al., 2022; Lu et al., 2022; Lu et al., 2023; Onyejegbu et al., 2023; Öz et al., 2022; Ramirez-Amaro et al., 2023)	Engineering, *N*= 20 (11)
(Arora et al., 2024; Azafrani & Gupta, 2023; Boulanin & Lewis, 2023; Brand, 2022; Gianni et al., 2022; Hacker & Passoth, 2022; Krafft et al., 2021; Krarup & Horst, 2023; Li & Yang, 2021; Meerveld et al., 2023; Pak, 2022; Upreti et al., 2023)	Governance, *N*= 12 (7)
(Al-Dhaen et al., 2021; Al-Hwsali et al., 2023; Borda et al., 2022; Cai et al., 2023; Calvo et al., 2023; Charalampakos et al., 2023; Cheng et al., 2021; El-Haddadeh et al., 2021; Fosso Wamba et al., 2021; Gaon & Stedman, 2019; Garg, 2023; Gilbert et al., 2023; Golbin et al., 2020; Gupta et al., 2021; Islam et al., 2023; Iwasawa et al., 2023; Jawad et al., 2021; Johnson et al., 2021; Jörg et al., 2023; Karagianni et al., 2023; Knopp et al., 2023; Kumar et al., 2021; Li et al., 2023; Liao et al., 2023; Liu et al., 2021; Marvin et al., 2022; Müftüoğlu et al., 2022; Prabhudesai et al., 2023; Roemmich & Andalibi, 2021; Rudd & Igbrude, 2023; Sivarajah et al., 2023; Szabo et al., 2022; Trocin et al., 2023.; Wang et al., 2021; Weekes & Eskridge, 2022; Wellnhofer, 2022)	Health, *N*= 36 (20)
(Agarwal & Mishra, 2021; Akbarighatar et al., 2023; Al Hashlamoun et al., 2023; Alibašić, 2023; Arya et al., 2023; Ayoubi et al., 2023; Baeza-Yates & Villoslada., 2022; Bani Ahmad, 2024; Belle, 2019; Bhattacharyya et al., 2023; Blockeel et al., 2023;	Science, *N*= 4 (24)

Christos et al., 2020; Church et al., 2022; De et al., 2023; Deshmukh & Srinivasa, 2022; Feher, 2021; Fritz-Morgenthal et al., 2022; Harfouche et al., 2024; Herrmann, 2023; Heuillet et al., 2022; Jaipuria et al., 2022; Ji et al., 2023; Kapania et al., 2023; Kumar et al., 2023; Liao et al., 2022; Lin, 2024; Liu et al., 2023; Mahoney et al., 2022; Merhi, 2023; Meske et al., 2022; Pisoni & Molnár, 2023; Pushkarna et al., 2022; Rantanen et al., 2021; Rivas et al., 2023; Rizinski et al., 2022; Roy & Salimi, 2023; Satish et al., 2023; Sothilingam, 2023; Souza et al., 2023; Tutun et al., 2022; Walsh et al., 2021; Weiss et al., 2023)	
(Alam, 2023; Aler Tubella et al., 2024; Anagnostou et al., 2022; Ansari et al., 2021; Barletta et al., 2023; Brumen et al., 2023; Buchholz et al., 2022; Buijsman, 2023; Cachat-Rosset & Klarsfeld, 2023; Calvo et al., 2020; Chang & Ke, 2023; Chen et al., 2023; Constantinescu et al., 2021; Contractor et al., 2022; Dennehy et al., 2023; Dholakia et al., 2023; Domínguez Figaredo et al., 2023; Dong et al., 2023; Farina, 2022; Grammatikos et al., 2023; Gwagwa et al., 2021; Hernández & Galanos, 2022; Inuwa-Dutse, 2023; Kapania et al., 2022; Karpagam et al., 2022; Kuennen, 2023; Lo et al., 2023; Lukkien et al., 2023; Mallinger & Baeza-Yates, 2024; Man Li & Crabbe, 2022; Maruyama, 2022; Marzouk et al., 2023; Methnani et al., 2023; Methnani et al., 2021; Mikalef et al., 2022; Minkkinen et al., 2024, 2023; Murray-Rust et al., 2023; Nedunuri, 2023; Ong & Findlay, 2023; Porayska-Pomsta, 2023; Reis et al., 2023; Rodier et al., 2023; Ruttkamp-Bloem, 2023; Sanderson et al., 2022, 2023; Satornino et al., 2024; Saxena et al., 2023; Scepanovic et al., 2023; Sinde et al., 2023; Stahl, 2022; Szczekocka et al., 2022; Tayebi & Garibay, 2023; Teixeira et al., 2023; Yang et al., 2020)	Social science, *N*= 55 (31) Total, *N*= 177 (100)

To help make the data collection process less biased, we employed a coding scheme and charted findings about our research questions. This implies that if each study's description fits the coding, it is charted appropriately. In doing we wish to make our data collection process more systematic and reproducible. A summary of coding for each research question can be found below:

1. What are the emergent principles of responsible AI?
    1. Empirical: mathematical or established theories from the literature as the guiding principle.
    2. Social: generic social norms and goals as the guiding principle.
    3. Empirical and social: an empirical and social set of principles used by the study.
2. What are the emergent research designs on responsible AI?
    1. Quantitative: empirical means of hypothesis testing, conducting studies, and collecting quantitative data with mathematical analysis
    2. Qualitative: thematic means of coding, reviewing, and summarizing qualitative data with the synthesis of information
    3. Mixed: quantitative and qualitative means of data collection and analysis were used by the study

    1. Prescriptive: implies the research findings on responsible AI offer insight, model, or tool that is prescriptive of future actions.
3. What are the emergent research challenges on responsible AI?
    1. Empirical: challenges with the mathematical models or theoretical aspects of research.
    2. Social: challenges with the social and societal aspects of research.
    3. Empirical and social: both empirical and social challenges.
4. What are the emergent research findings on responsible AI?
    1. Descriptive: what had been done in the past.
    2. Diagnostics: what actions have been done correctly or incorrectly in the past.
    3. Predictive: predicts future actions.
    4. Prescriptive: offers actionable recommendations for the future.
5. Putting it together: What is the Research Landscape on Responsible AI? That is what is emergent principle-research design-findings-challenges on responsible AI?

We analyze data collected for each of our research questions through descriptive summaries of codes and frequency counts of derived text. A complete summary of data collected from our review is summarized in Table 8 and can be found in the Appendix. The descriptive tables present the count of each category against the total counts of that category, leading to a percentage of the area. We use this along with a thematic review of codes to inform emergent trends and highlight strengths and weaknesses in research around responsible AI across the derived areas of Business, Engineering, Governance, Health, Science, and Social Science.

LIMITATIONS

We acknowledge that this study comes with limitations. We broadly search for responsible AI and so our work only provides a high-level picture of research on responsible AI across different areas. We only included studies in English and did not include tertiary publications.

RESULTS

This section shares the findings of the review and coding of each of our research questions.

Principles

A descriptive summary of principle types employed within the areas of reviewed studies can be found in Table 3. Within the areas of Business and Engineering, Social principles were used the most, and the combination of social and empirical principles was used the least. Within the areas of Governance and Social Science, Social principles were used the most, and empirical-only principles were used the least. Within the areas of Health and Science, the combination of social and empirical principles was used the most, and social principles were used the least.

The word ethics is an emergent principle across the six areas and overall. Within the area of Business, principles are more regulatory and in the form of guidelines. Within the area of

Engineering, principles are a social examination of technical contexts. Terms that are often associated with responsible technical AI such as transparency, accountability, explainability, safety, security, accident, and privacy are seen in Engineering. Within the area of Governance, the safety and privacy principles held at an organizational level are an emergent theme of principles. Within the area of Health, principles are a social examination of healthcare designs and systems. Terms that are often associated with responsible medical AI such as transparency, non-maleficence, explanation, justice, and transparency are seen in Health. Within the areas of Social Science, terms such as fairness, transparency, accountability, nondiscrimination, safety, and privacy are emergent themes within the reviewed studies.

Table 3. Descriptive summary of principles across areas

AREA	EMPIRICAL	SOCIAL	EMPIRICAL AND SOCIAL
Business (7)	25.00	58.33	16.67
Engineering (11)	25.00	45.00	30.00
Governance (7)	16.67	50.00	33.33
Health (20)	30.56	27.78	41.67
Science (24)	38.10	19.05	42.86
Social science (31)	14.55	60.00	25.45
Overall	25.42	41.24	33.33

RESEARCH DESIGNS

A descriptive summary of research designs and analyses employed within the areas of reviewed studies can be found in Table 4. Within the areas of Business, Health, and Science, Qualitative studies are reported the most, followed by quantitative, and a combination of qualitative and quantitative studies are reported the least. Within the areas of Governance and Social Science, Qualitative studies are reported the most, followed by a combination of qualitative and quantitative studies, and quantitative studies are reported the least. Within the area of Engineering, quantitative and combination of quantitative and qualitative studies are reported the most and the qualitative challenges are reported the least. Overall qualitative challenges are most reported, followed by quantitative and a combination of qualitative and quantitative challenges.

Examples of quantitative studies include improving classification using hierarchical conditional multi-class, smart contracts, and models that enable comprehension of the implications and consequences of AI use. Examples of qualitative studies include literature reviews, societal frameworks of AI, and qualitative survey questionnaires. Examples of mixed methods studies include a review of the role of decision trees, speculative design and interview on a model, course designs, and mathematical modeling of responsible decision-making.

Table 4. Descriptive summary of research design/analysis across areas

AREA	QUANTITATIVE	QUALITATIVE	MIXED
Business (7)	25.00	58.33	16.67
Engineering (11)	35.00	30.00	35.00
Governance (7)	8.33	58.33	33.33
Health (20)	36.11	41.67	22.22
Science (24)	28.57	52.38	19.05
Social science (31)	10.91	69.09	20.00
Overall	23.73	53.67	22.60

RESEARCH CHALLENGES

A descriptive summary of research challenges within the areas of reviewed studies can be found in Table 5. Except for the area of Science, all other areas report Social or a combination of Social and Empirical challenges the most. For Science, Empirical challenges are reported the most. Examples of empirical challenges are integrating RAI mathematically in the data science lifecycle, inaccurate uses of harmonized systems, and identifying a true set of features for predictive analysis.

Examples of social challenges are controllability and sharing authority between humans and AI agents, addressing unfavorable outcomes, enabling civic participation, and impact of personal experiences. Examples of empirical and social challenges are conflicting goals, democratic shortfalls, opportunity risks, costs and uncertainty, and unparalleled contexts.

Table 5. Descriptive summary of research challenges across areas

AREA	EMPIRICAL	SOCIAL	EMPIRICAL AND SOCIAL
Business (7)	33.33	25.00	41.67
Engineering (11)	30.00	35.00	35.00
Governance (7)	8.33	41.67	50.00
Health (20)	22.22	41.67	36.11
Science (24)	38.10	28.57	33.33
Social science (31)	20.00	50.91	29.09
Overall	25.99	39.55	34.46

RESEARCH FINDINGS

A descriptive summary of research findings with AI within the areas of reviewed studies can be found in Table 6. All areas except for Engineering shared descriptive findings the most, and for Engineering descriptive findings were noted the most. The least shared findings were diagnostic for Business, Prescriptive for Engineering, Predictive for Governance, Health and Social Science, and Diagnostic for Science.

Examples of Descriptive findings include highlighting key factors (e.g., accountability and explainability), needed interdisciplinary discussions, and types of audit planning risk assessments taken by companies. Examples of Diagnostic findings include model checking for human-agent collectives, and proposing models or algorithms that can find deficits in the responsibility of AI. Examples of Predictive findings include the use of the Internet of Things (e.g., medical or IoMT) to continuously learn and help predict patterns in future data or events. Examples of Prescriptive findings include. research roadmap, frameworks, and best practices proposed to enhance the responsibility of AI.

Table 5. Descriptive summary of research findings across areas

AREA	DES=-CRIPTIVE	DIAGNOSTIC	PREDICTIVE	PRES-CRIPTIVE
Business (7)	66.67	0.00	25.00	8.33
Engineering (11)	35.00	45.00	15.00	5.00
Governance (7)	50.00	25.00	8.33	16.67
Health (20)	61.11	22.22	5.56	11.11
Science (24)	78.57	4.76	7.14	9.52
Social science (31)	56.36	23.64	7.27	12.73
Overall	60.45	19.77	9.04	10.73

PUTTING IT TOGETHER

A descriptive summary of research trends can be found in Table 7. As can be seen in Table 7, frequent trends per area are rather low and each study within each area and overall devises different assortments of principle types, research design, and data analyses, and discovers different challenges and findings. Yet, overall social principles, qualitative analysis, social challenges, and descriptive findings tend to be the predominant research trend. A largely qualitative and social type of research on responsible AI may bring both benefits and disadvantages to our understanding of responsible AI. Next, we aim to summarize the findings of our review and present new conceptions and directions for future research.

Table 7. Descriptive summary of frequent research trends across areas

AREA	TOP TREND	MEANING
Business (7)	2331 (*1*)	Social principle, mixed analysis, empirical and social challenges, descriptive findings
Engineering (11)	2221 (*1*)	Social principle, qualitative analysis, social challenge, descriptive findings
Governance (7)	2222 (*1*)	Social principle, qualitative analysis, social challenge, diagnostic findings
Health (20)	1112 (*3*)	Empirical principle, quantitative analysis, empirical challenge, diagnostic findings
Science (24)	3231 (*3*)	Mixed principle, quantitative analysis, empirical challenge, descriptive findings
Social science (31)	2221 (*5*)	Social principle, qualitative analysis, social challenge, descriptive findings
Overall		**Social principle, qualitative analysis, social challenge, descriptive findings**

DISCUSSION

In this work, we sought to gain a big-picture overview of the state of research on responsible AI. Through a review of 1224 studies across 7 databases, a total of 177 studies fit our criteria and explored responsible AI within one of six areas of Business, Engineering, Governance, Health, Science, and Social Science.

SUMMARY OF FINDINGS

We first identified and explored the areas and demographics of publications within the reviewed studies (see Table 1 and Table 2). We found that the highest number of publications were in social science, followed by science, health, and engineering, and the two areas of business and governance the least. This trend may suggest the need to make responsible AI in general and applied sciences streamlined more. What may make the characterization of responsible AI particularly difficult in governance and business can be conflicting financial versus humanistic motives by opposing stakeholders and the more prominent presence of dilemmas about responsible behavior in the two fields.

When examining the key terms, we found emergent associations of management for business, the bias for engineering, decision-making for governance, computing for health, data for science, and education for social science. These terms may signal what is deemed more representative of responsible behavior and outline the differences in perspective that exist surrounding responsible AI across the fields.

The journal followed by conference papers was the emergent type of research dissemination. We also see a surprisingly high number of publications overall in 2023 in comparison to the prior years. These may suggest that responsible AI is a newly found and hot topic that is currently receiving increased attention in the literature with interest in rapid

dissemination in the form of journal and conference articles. The lack of a high number of books on responsible AI across areas also indicates that all areas are struggling to find a standardized and generalizable definition and approach to responsible AI.

A descriptive codification of principles (i.e., either empirical, social, or empirical and social) across the six areas and overall revealed that Social principles are most often employed as building theories and principles of responsible AI. We also found that Business and Engineering, Governance and Social Science, and Health and Science share similar profiles of principles that are largely social. This makes sense given that responsible behavior in nature is a social construct and must have humanistic traits and is thus naturally foreign to empirically guided algorithms and AI applications. The unifying emphasis on social principles around responsible AI suggests that more discussion and enhancement to the social conceptualizations are needed. Further, work is needed to reformulate such social principles appropriately (e.g., accurately, and ethically) into a language that is understandable and readily understood by AI applications.

The principle of responsible AI is often associated with terms such as accountability, transparency and explainability, justice and fairness, non-maleficence, security, and privacy. This may suggest that AI manifests itself the most within the data pipeline and design of systems across different areas, and social construction of and consensus on responsible AI is needed. We also found that within Business the principles are more regulatory responsibility, in Engineering more technical responsibility, in Governance more organizational responsibility, in Health more medical responsibility, in Science more learning and design responsibility, and in social science, more equity and fairness responsibility is needed. These terms again highlight what is deemed more important across different areas and perhaps can hint at where more efforts need to be put into improving principles of responsible AI across different areas.

Research design tends to be qualitative with responsible AI. This makes sense as the fundamentals of responsibility have a subjective, interpretive, and socially constructed nature. We find either quantitative or qualitative studies often create vastly different conceptions of responsible AI. Quantitative studies are mathematical, theoretical, and algorithmic, and often deal with technology, designs, and procedures to make AI responsible in empirical ways. Qualitative studies are interpretive, and subjective, and often discuss and disseminate an understanding of what constitutes AI responsibility. Mixed studies employ a combination of empirical measurements and subjective perceptions and experiences of individuals toward responsible AI. While each research design and data analysis approach offers a unique perspective on responsible AI, more work may be needed to connect and make different research designs interoperable. For example, a challenge for future work may be on how to quantitatively characterize the many notions and needs of responsible AI appropriately.

Except for the area of Science, all other areas report Social or a combination of Social and Empirical challenges the most. For Science, Empirical challenges are reported the most. This finding highlights the dominant role of social gaps and needs that need to be accounted for and addressed with research on responsible AI. For example, even areas such as Engineering that use empirical research design and analysis the most found to be facing social challenges concerning responsible AI the most.

We find an abundance of descriptive findings surrounding responsible AI, and less work on developing diagnostic, predictive, and prescriptive research findings on responsible AI.

Diagnostic models can help inform where AI responsibility went wrong in the past. Predictive models can help hypothesize where AI responsibility may go wrong in the present or future. Prescriptive models can help propose corrective actions or guidelines on how to always safeguard responsible AI use.

Overall, we find research across areas to devise different assortments of principle types, research designs, and data analyses, and discover different challenges and findings. Yet, when looking holistically over the areas combined, we find the emergent research to be using social principles, qualitative analyses reporting on social challenges, and descriptive findings. There may thus need to be more harmonized and continuous research efforts to bridge the gap between empirical theory and practice and qualitative and social notions and needs of responsible AI.

IMPLICATIONS

The review of 177 studies across six areas presents both underlying and different implications. Examples of universal and underlying implications are the ever-expanding notions of ethics, such as accountability, explainability, transparency, justice, non-maleficence, accountability, and privacy. There is such a possibility that RAI's boundaries and terms are infinite and evolving with time. The future progression of AI, along with social-political powers may dictate to what degree humans can intervene and characterize responsible AI appropriately. Below, we present example implications for each of the six areas of Business, Engineering, Governance, Health, Science, and Social Science.

In Business, applications such as smart contracts may safeguard the responsible and ethical growth of AI. Yet, they remain a technique and technology for privacy, and so their expanded and increased use may also be susceptible to hacks and newly found issues. In Engineering, traditional policy development and execution may be evaluated by selected representatives' checks. Identifying who and when may qualify as a representative, however, may become difficult when there are so many unique attributes of each individual, and aggregating them into representative classes or profiles of groups becomes multi-optional. The verification results through counterexamples and simulation results may enable more intuitive and comprehensive model checking for the AI engineer. This presumes that every example fed the model has a clear-cut counterexample with a robust opposing result. If however, the actions and their results are assumed to spread in a fuzzy, rather than a binary spectrum, having a counter-example for every scenario may be overly simplistic or hard to characterize. In governance, stakeholder participation and public confidence may be needed for incorporating AI into governance decision-making processes. A challenge may become the emergence of AI technology itself as a stakeholder, since its intelligence may give it power to have or impose needs of its own. As such public opinion may become understood and explained through the lens of AI technology, which may be narrow and fragmented in ways it understands and expresses the world (e.g., classification, clustering).

In health, awareness about AI may provide knowledge about the problems it may introduce such as ethical and moral ones in healthcare education. Yet, a monotonic view of AI use in healthcare education may divert attention from real-world humanistic ethical and moral challenges that may be left unnoticed or become hidden with the use of AI. As such there may be two stories of responsible healthcare practices that need to be written in tandem,

namely responsible healthcare practice both in the presence and absence of AI. In healthcare, various ethical principles may need to be considered. Examples are Health Equity, Accountability, Avoiding Unfair Bias, Security and Privacy, Confidentiality, Safety, Transparency, Social Justice, and Autonomy. Using AI may help make diagnoses more accurate and informed, yet it may also allocate more responsibility and accountability to the AI, making the human expert less informed and responsible. This may in the long run impact patient's sense of trust and health care responsibility and create new challenges of its own. For example, new concerns may emerge such as now that the responsible AI made a false diagnosis, what counter or next steps need to be carried out and should the irresponsibility be mitigated.

In Science, AI trading may introduce new risks and variables into the financial ecosystem. A question thus becomes whether existing financial systems can adapt and transition to accept AI within their social and empirical frameworks. Whereas in sectors such as healthcare more knowledge of AI may lead to enhanced quality of human life, in some other areas such as finance and politics the dependency on AI may degrade and take away human's goals. When training data is unreliable, modeling may be achieved using a Named Entity Recognition model or NER. The NER itself, however, extracts information from the text and may be generalizable the best to the text itself and no other instances where data is unreliable.

In Social Science, connecting and filling the gap between the social and technical notions of responsible AI is difficult, yet the challenge does not end here. Humans and even AI programs may have different interpretations of responsibility within each of the social and technical notions. For example, the construction and thresholds of transparency may differ across individuals and contexts, making the enactment of responsible AI variables as well as difficult to validate. Governments and regulatory organizations can play an important role in establishing standards for sustainability. A consideration, however, is to know if and how the governments and regulatory organizations use their AI systems their own and the impact of distributed uses of types of artificial intelligence on governance and the quality of humans' lives.

NEW CONCEPTIONS AND DIRECTIONS

Our review of 177 studies informed efforts that have been persistently and least used. Here we aim to suggest areas of consideration for future work that may help improve research and insight into responsible AI.

PRINCIPLES

In this work, we coded principles to be of social, empirical, or combination nature. We should note that all principles, whether hard coded and static or dynamic and transient, are socially developed and established constructs. Principles are often set by a language and logic understandable by humans, and so are largely informed semantics set by humans. Moreover, principles are understood and used differently by humans and teams of entities (Oliver, D., & Jacobs, 2007). We attempted to separate principles by attributing those that are more driven by scientific theories as empirical and humans' needs and challenges as social. We followed

this lens and identified that overall, most of the work on responsible AI is more social, rather than empirical or combination nature. This finding points to a lack of empirical formulations of responsible AI and an abundance of human perspectives and opinions on responsible AI. Together, these two findings can highlight a challenging concern that awaits us with the increased use of AI. That is how can we enable the so many different social constructions of responsible AI to co-exist and further be able to link the social with empirical principles and characterize them in more theoretical terms? Principles of responsible AI may need to transcend social or theoretical perspectives and delve further into principles of behavior (Hull, 1943), principles that can be causal or dynamic (Dishop et al., 2020), and so on. Even within each of the social and empirical or combination principles, the rules of thumb may change particularly within and across different areas. For example, the statistical principles may come to be different or follow different protocols of validation under different circumstances within a business or when comparing business with health. Therefore, we find the notion of principle making and setting to be a complex, multifaceted, and nested concept that needs further discussion and classification.

RESEARCH DESIGN

In this work, we also coded research designs to be of qualitative, quantitative, or combination methods. We came to find prior research mostly employs qualitative methods. A key reason for this could be because responsible AI, even if denoted purely algorithmically or statistically, is understood through the impact it has on humans (e.g., stakeholders such as designers or users) and their needs (Deshpande & Sharp, 2022). As a result, responsible AI is often measured and evaluated based on humans' self-reported experiences and concerns (Sartori & Bocca, 2022). Future research designs thus may need to offer mechanisms for more exact, reproducible, and quantifiable, hence quantitative collection and analysis of responsible AI. Much of this may be achieved with future breakthroughs of portable, non-invasive, and accurate modeling of humans' brains and mathematical formulations of perceptions and experiences (Gazzaniga, 2013; S. J. Morse, 2006). But until then, we may need to focus on how to quantitatively chunk down complex and comprehensive notions of responsible AI and help make social consensus on what does or does not qualify as appropriate research design to implement, measure, or assess responsible AI.

RESEARCH CHALLENGES

In this work, we further coded research challenges to be of empirical, social, or combination types. Again, we found social challenges to be the most but interestingly, the empirical and combination challenges were not very far social challenges, suggesting all sorts of challenges exist in light of predominant social principles and qualitative research designs. The findings highlight that the study and execution of responsible AI have two important dimensions, namely how we perceive and use it socially and qualitatively as humans and how we come to be challenged both socially and empirically in the presence of AI in the loop. Since much of the logic and existence of AI is empirical, even its non-empirical applications lead to empirical challenges mainly because algorithms, numeric classification, and clustering are the drivers and backbone of what constitutes AI (Simon, 1995). A direction for future work,

perhaps in the opposite direction to probing and quantifying humans' brains, thinking, and emotions, may be to make the logic, explanation, and algorithms behind AI more qualitative by stripping away AI from its predominant quantitative semantics. This direction may be even more promising, given that AI's logic is likely to supersede that of humans. By making AI language and logic of nature that is natural to humans, even the most advanced notions of AI may still be readily digestible by humans. Yet, there is a lingering concern of deceit and mismatched explanations from the AI side.

RESEARCH FINDINGS

In this work, we further coded the findings of research on responsible AI to be descriptive, diagnostic, predictive, or prescriptive. We found descriptive studies to be dominant with a high lead in comparison to diagnostic, predictive, or prescriptive findings. This is concerning because it suggests that research is good in describing responsible AI but falls behind in identifying and troubleshooting where responsible AI falls short, predicting the presence or absence of responsible AI, and prescribing actions to maintain responsible AI in present or future times. This finding may highlight that we are in an infantry state of research on responsible AI and much more discussions and work is needed to characterize, execute, and enforce responsible AI.

CONCLUSION

Rooted in a grounded theory approach, the goal of this research was to review literature across diverse domains emerging from the studies (i.e., science, engineering, governance, social views, and science) and identify research trends related to responsible artificial intelligence (AI). Our review suggests that different areas devise different assortments of principle types, research designs, and data analyses, and discover different challenges and findings. Despite this diversity across the studied areas, research on responsible AI is inherently rooted and bounded by the social perceptions and needs of humans and empirical formulations and mechanisms of AI. A key challenge and goal of future work thus needs to align these two by either making humans more easily understand the empirical language of AI or conversely stripping AI away from a mathematical and empirical conception and reconstructing a new kind of AI that is solely social in a humanistic way, qualitative, and natural to humans' language, semantics, goals, and address responsible behavior in a universally acceptable way.

AVAILABILITY OF DATA AND MATERIAL

The author confirms that all data generated or analyzed during this study are included in this published article.

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CONFLICT OF INTEREST

None.

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Appendix

Table 8
Overview of the reviewed studies paradigm, AI use, and sector

Area	Reference	Area: 1=business, 2=engineering, 3=governance, 4=health, 5=science, 6=social views and education)	Type: C=Conf, J=Journal, B=Book, BC=Book Chapter, LN=Lecture Notes, PP=Preprint	Principles: 1=empirical, 2=social	Design research: 1=quant, 2=qual, 3=mixed	Challenge: 1=empirical, 2=social, 3=both	Findings: 1=descriptive, 2=diagnostic, 3=predictive, 4=prescriptive
2	(Abeywickrama et al. , 2019)	2	J	2	3	2	2
5	(Agarwal & Mishra, 2021)	5	B	3	2	1	1
5	(Akbarighatar et al. , 2023)	5	J	2	2	3	1
5	(Al Hashlamoun et al. , 2023)	5	C	2	2	2	1
6	(Alam, 2023)	6	J	1	1	1	1
4	(Al-Dhaen et al., 2021)	4	J	3	2	2	3
6	(Aler Tubella et al. , 2024)	6	C	1	1	1	2
2	(Alfrink et al. , 2023)	2	C	3	3	2	2
4	(Al-Hwsali et al., 2023)	4	J	2	2	3	1
5	(Alibašić, 2023)	5	J	1	2	2	1
6	(Anagnostou et al. , 2022)	6	C	1	1	3	3
6	(Ansari et al. , 2021)	6	J	1	2	1	2
3	(Arora et al. , 2024)	3	LN	1	3	3	1
5	(Arya et al. , 2023)	5	C	1	1	1	1
1	(Asif et al. , 2023)	1	J	3	1	1	1
5	(Ayoubi et al. , 2023)	5	C	3	2	3	1
2	(Öz et al. , 2022)	2	J	2	2	3	1
3	(Azafrani & Gupta, 2023)	3	J	3	2	2	1
5	Baeza-Yates & Villoslada, 2022)	5	C	2	2	2	2
5	(Bani Ahmad, 2024)	5	J	1	2	2	1
2	(Bao et al. , 2023)	2	J	2	3	3	2
6	(Barletta et al. , 2023)	6	J	1	2	2	1
5	(Belle, 2019)	5	J	2	2	3	1
5	(Bhattacharyya et al., 2023)	5	C	1	1	1	1
5	(Blockeel et al., 2023)	5	J	1	3	3	1
4	(Borda et al. , 2022)	4	J	2	2	2	1

3	(Boulanin & Lewis, 2023)	3	J	2	2	2	2
3	(Brand, 2022)v	3	J	2	2	3	3
6	(Brumen et al. , 2023)	6	J	1	2	3	4
6	(Buchholz et al. , 2022)	6	J	1	3	1	2
6	(Buijsman, 2023)	6	C	1	3	2	2
6	(Cachat-Rosset & Klarsfeld, 2023)	6	C	2	1	1	1
4	(Cai et al. , 2023)	4	C	1	1	1	2
4	(Calvo et al., 2023)	4	C	1	1	1	2
6	(Calvo et al. , 2020)	6	J	2	1	2	1
6	(Chang, Y. L. , & Ke, 2023)	6	J	2	2	1	1
4	(Charalampakos et al. , 2023)	4	C	1	1	1	2
6	(H. Chen et al. , 2023)	6	C	2	2	1	2
4	(Cheng et al. , 2021)	4	J	1	1	3	1
5	(Christos et al. , 2020)	5	C	1	1	1	4
5	(Church et al., 2022)	5	J	2	2	3	1
6	(Constantinescu et al. , 2021)	6	C	2	2	1	4
6	(Contractor et al., 2022)	6	J	2	2	2	1
1	(Crockett et al., 2023)	1	J	2	3	3	1
2	(De Brito Duarte, 2023)	2	J	2	1	3	4
5	(De et al. , 2023)	5	PP	3	1	1	1
2	(Delecraz et al., 2022)	2	J	3	1	1	3
6	(Dennehy et al. , 2023)	6	J	2	2	2	1
5	(Deshmukh & Srinivasa, 2022)	5	J	2	1	1	1
6	(Dholakia et al. , 2023)	6	C	2	2	2	1
6	(Domínguez Figaredo et al. , 2023)	6	C	2	2	2	1
2	(Dominique et al. , 2023)	2	C	3	3	2	2
6	(Dong et al. , 2023)	6	J	2	2	2	1
4	(El-Haddadeh et al. , 2021)	4	J	3	3	3	2
2	(Faßbender, 2021)	2	C	1	2	2	1
2	(Falco, 2019)	2	C	2	2	2	1
6	(Farina, 2022)	6	J	2	2	2	1
1	(Fenwick et al. , 2018)	1	BC	2	2	3	3
1	(Ferreira et al. , 2023)	1	C	2	3	3	1
4	(Fosso Wamba et al. , 2021)	4	J	3	3	3	1
5	(Fritz-Morgenthal et al. , 2022)	5	J	3	2	2	4
4	(GAON & STEDMAN, 2019)	4	LN	3	2	3	4
4	(Garg, 2023)	4	J	3	1	3	3
5	(Feher, 2021)	5	B	3	3	3	1
2	(Gavrilova, 2023)	2	C	2	2	3	1
3	(Gianni et al. , 2022)	3	J	2	2	2	1
4	(Gilbert et al. , 2023)	4	LN	1	1	1	2
4	(Golbin et al. , 2020)	4	C	2	2	3	1

6	(Grammatikos et al., 2023)	6	J	2	2	2	1
4	(Gupta et al., 2021)	4	J	3	2	3	1
6	(Gwagwa et al., 2021)	6	C	2	2	2	1
3	(Hacker & Passoth, 2022)	3	J	3	2	3	4
1	(Hadley, 2022)	1	C	2	2	2	3
1	(Haidar, 2024)	1	J	1	2	3	4
5	(Harfouche et al., 2024)	5	J	3	2	3	1
6	(Hernández & Galanos, 2022)	6	C	2	2	2	1
5	(Herrmann, 2023)	5	J	3	2	2	1
5	(Heuillet et al., 2022)	5	C	1	1	1	3
2	(Hu, 2023)	2	C	1	3	1	2
6	(Inuwa-Dutse, 2023)	6	J	2	2	2	2
4	(Islam et al., 2023)	4	C	3	3	1	1
4	(Iwasawa et al., 2023)	4	J	3	1	2	1
4	(Jörg et al., 2023)	4	J	2	2	2	1
5	(Jaipuria et al., 2022)	5	C	1	1	1	1
4	(Jawad et al., 2021)	4	C	2	2	2	1
5	(Ji et al., 2023)	5	C	1	1	2	1
4	(Johnson et al., 2021)	4	J	3	1	1	1
2	(Kamada, 2016)	2	C	2	1	2	2
6	(Kapania et al., 2022)	6	J	2	2	2	3
5	(Kapania et al., 2023)	5	C	3	2	3	1
4	(Karagianni et al., 2023)	4	C	1	1	3	4
6	(Karpagam et al., 2022)	6	J	2	2	2	3
4	(Knopp et al., 2023)	4	J	2	2	2	4
3	(Krafft et al., 2021)	3	C	2	3	3	1
3	(Krarup & Horst, 2023)	3	J	3	3	2	2
2	(Kuck, 2023)	2	C	3	1	1	1
6	(Kuennen, 2023)	6	J	2	2	2	4
5	(K. P. Kumar et al., 2023)	5	BC	3	1	1	1
4	(P. Kumar et al., 2021)	4	J	1	3	2	1
2	(Lee et al., 2024)	2	J	1	3	3	1
2	(Lescano et al., 2023)	2	J	1	1	3	2
2	(Lewis et al., 2022)	2	J	3	1	1	3
3	(C. Li & Yang, 2021)	3	C	2	2	3	1
4	(K. Li et al., 2023)	4	C	3	2	3	1
5	(Q. V Liao et al., 2022)	5	C	3	3	3	1
4	(W. Liao et al., 2023)	4	J	1	1	2	2
5	(Lin, 2024)	5	J	3	2	1	1
5	(J. Liu et al., 2023)	5	C	1	3	3	1
4	(R. Liu et al., 2021)s	4	J	2	2	2	1

6	(Lo et al., 2023)	6	J	2	2	2	4
2	(Lu et al., 2023)	2	J	2	2	3	2
2	(Lu et al., 2022)	2	C	2	2	2	1
6	(Lukkien et al., 2023)	6	C	2	2	3	1
4	(Müftüoğlu et al., 2022)	4	J	2	3	3	1
5	(Mahoney et al., 2022)	5	C	1	1	2	4
1	(Maki et al., 2023)	1	J	3	2	2	1
6	(Mallinger & Baeza-Yates, 2024)	6	J	2	2	3	1
6	(Man Li & Crabbe, 2022)	6	J	2	2	3	1
1	(Marcoux & Martineau, 2022)	1	J	2	2	2	1
1	(Maree et al., 2020)	1	C	1	1	1	1
6	(Maruyama, 2022)	6	J	2	2	3	2
4	(Marvin et al., 2022)	4	C	1	1	2	2
6	(Marzouk et al., 2023)	6	J	2	2	3	2
3	(Meerveld et al., 2023)	3	J	2	2	2	2
5	(Merhi, 2023)	5	J	3	2	2	2
5	(Meske et al., 2022)	5	J	3	2	3	1
6	(sMethnani et al., 2023)	6	J	2	2	3	4
6	(Methnani et al., 2021)	6	PP	2	3	2	1
6	(Mikalef et al., 2022)	6	C	2	3	2	1
6	(Minkkinen et al., 2024)	6	J	2	3	2	1
6	(Minkkinen et al., 2023)	6	C	2	3	2	2
6	(Murray-Rust et al., 2023)	6	J	2	3	3	1
1	(Narayanan, 2023)	1	J	2	2	1	1
6	(Nedunuri, 2023)	6	J	2	3	3	4
6	(Ong & Findlay, 2023)	6	J	3	1	1	3
2	(Onyejegbu et al., 2023)	2	J	1	1	1	2
3	(Pak, 2022)	3	BC	1	1	1	1
1	(E. Papagiannidis et al., 2022)	1	J	1	1	1	3
5	(Pisoni & Molnár, 2023)	5	J	1	2	1	1
6	(Porayska-Pomsta, 2023)	6	J	3	2	1	1
4	(Prabhudesai et al., 2023)	4	J	1	1	1	2
5	(Pushkarna et al., 2022)	5	J	3	3	1	1
2	(Ramirez-Amaro et al., 2023)	2	J	3	3	1	3
5	(Rantanen et al., 2021)	5	J	3	2	2	1
6	(Reis et al., 2023)	6	J	3	2	2	2
5	(Rivas et al., 2023)	5	BC	3	2	3	1
5	(Rizinski et al., 2022)	5	J	1	3	3	3
6	(Rodier et al., 2023)	6	J	3	2	2	1
4	(Roemmich & Andalibi, 2021)	4	J	3	1	2	1
5	(Roy & Salimi, 2023)	5	BC	2	2	1	1

4	(Rudd & Igbrude, 2023)	4	J	2	2	3	1
6	(Ruttkamp-Bloem, 2023)	6	J	3	2	2	2
6	(Sanderson et al., 2023)	6	J	3	2	2	2
6	(Sanderson et al., 2022)	6	C	3	2	2	2
5	(Satish et al., 2023)	5	C	1	3	1	1
6	(Satornino et al., 2024)	6	J	3	2	2	4
6	(Saxena et al., 2023)	6	J	3	2	3	1
6	(Scepanovic et al., 2023)	6	J	3	2	3	1
6	(Sinde et al., 2023)	6	C	3	2	3	1
4	(Sivarajah et al., 2023)	4	J	1	2	2	4
5	(Sothilingam, 2023)	5	C	1	2	3	1
5	(Souza et al., 2023)	5	C	3	3	1	4
6	(STAHL, 2022)	6	C	3	2	3	1
4	(Szabo et al., 2022)	4	J	3	2	2	1
6	(Szczekocka et al., 2022)	6	J	3	3	1	1
6	(Tayebi & Garibay, 2023)	6	B	3	3	3	1
6	(Teixeira et al., 2023)	6	PP	2	2	3	1
4	(Trocin et al., 2023)	4	J	3	3	2	1
5	(Tutun et al., 2022)	5	J	3	1	2	1
3	(Upreti et al., 2023)	3	J	3	3	3	4
1	(Wach et al., 2023)	1	J	2	2	3	1
5	(Walsh et al., 2021)	5	C	1	1	1	3
4	(W. S. Wang et al., 2021)	4	J	3	3	3	1
4	(Weekes & Eskridge, 2022)	4	BC	2	3	1	1
5	(Weiss et al., 2023)	5	BC	2	2	2	1
4	(Wellnhofer, 2022)	4	J	3	2	2	1
6	(Yang et al., 2020)	6	J	2	3	2	1

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COLLABORATIVE DEVELOPMENT ON A DIGITAL LEARNING PLATFORM: THE POTENTIAL OF AI TOOLS FOR FACILITATION

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Abstract: *Digital learning platforms featuring artificial intelligence (AI)-based tools are being increasingly used at workplaces. This study investigated the opportunities that AI tools offer for facilitating the collaborative development of work on a learning platform called Howspace. The data comprised interviews with platform developers (n=4) and facilitators (n=10). Content analysis explored the interviewees' conceptions of the use of AI tools in collaborative development. It identified four AI tool functions—task assistant, participant assistant, process assistant, and interaction assistant—along with their associated benefits and limitations. Platform developers saw more opportunities for the use of AI tools, whereas the facilitators saw more challenges. These challenges were primarily related to the facilitators' limited understanding of the algorithms' logic. The study proposes that enhancing the transparency of algorithms could improve the usability of AI tools. A better understanding of algorithmic operations could mitigate the identified challenges, and improve facilitators' experience of employing AI tools.*

Keywords: *artificial intelligence, learning platforms, collaborative development, work development, facilitation.*

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INTRODUCTION

Digital learning platforms that use artificial intelligence (AI)-based tools and applications have been created to support collaborative development (Ouyang, Xu, & Cukurova, 2023; Roll & Wylie, 2016; Rummel, Walker, & Aleven, 2016; Schaefer, Rahn, Kopp, Fabian, & Brown, 2019). By the collaborative development of work we refer to the interactional activities through which a work community or work group identify and solve work-related problems, and design and create something of use value, such as new practices, artifacts or concepts (see Engeström, 2008; 2022). AI, in turn, refers to the various computational applications that perform the cognitive and interactive tasks that usually require human intelligence and reasoning (Luckin, Holmes, Griffiths, & Forcier., 2016; Rienties, Køhler Simonsen, & Herodotou, 2020). These tasks include analyzing natural language, images, or visual environments, and organizing and evaluating information (e.g., Russell & Norvig, 2016).

The evolution of learning platforms has mostly been driven by technological innovations (Dillenbourg, 2016), and the rapid development of generative AI is creating further opportunities for learning and development (see Johnson, 2023; Kaczorowska-Spychalska, Kotula, Mazurek, & Sułkowski, 2024; Mhlanga, 2023). AI also offers potential support for interaction and building shared knowledge (Ferreira-Mello, André, Pinheiro, Costa, & Romero, 2019; Kalakoski, Koskela, Kurki, Toivanen, & Yli-Kaitala, 2021; Maity, 2019; Schaefer et al., 2019), which can help overcome some of the challenges related to learning platforms such as limited interaction and difficulty expressing opposing views (Yoon, Miller, Richman, Wendel, Schoenfeld, Anderson & Shim, 2020). Like other technological innovations, AI generates social innovations (see Pérez, 2002) by, for example, affecting how development activities are conducted and facilitated (see Dillenbourg 2016; Kaczorowska-Spychalska et al., 2024; Leonardi & Treem, 2020). However, the fact that the use of AI inevitably affects social systems has received less attention from scholars (Wojciechowski & Korjonen-Kuusipuro, 2023).

Artificial intelligence in education (AIED) provides a useful framework for examining AI-assisted collaborative development in the work life context (e.g., Pammer-Schindler & Rosé, 2022). So far, the main emphasis of AIED has been on educational settings (Niemi, Pea, & Lu, 2023), and few studies have focused on the work life context. Furthermore, these rare studies have primarily focused on developing tutoring systems, supporting individual employees' skills, and addressing data-related ethics (Porayska-Pomsta, 2016; Sottilare et al., 2018; Pammer-Schindler & Rosé, 2022). AI–human collaboration is an important but still underexplored theme that needs more attention in various contexts (Bhimdiwala, Neri, & Gomez, 2022; Brusilovsky, 2023; Chounta, Bardon, Raudsep, & Pedaste, 2021).

This study expands the context of AIED research to work development and examines AI–human collaboration, specifically the potential of AI-based tools to support the *facilitation* of collaborative development processes. By facilitation we refer to the intentional actions through which the (human) facilitator supports collaborative development on a digital platform. The facilitator prepares the process and tools, executes the planned tasks, and advances the process by asking questions and encouraging participants to share their ideas and perspectives (Clottes Heikkilä & Kurki, 2024). Our interest was in the platform developers' and facilitators' conceptions of the opportunities that specific AI tools offer

collaborative development on a learning platform. Our aim was to investigate how the use of AI tools impacts the work of the facilitator, and what limitations the tools are perceived to have.

AI-ENHANCED COLLABORATIVE WORK DEVELOPMENT ON DIGITAL PLATFORMS

AIED Technologies in Collaborative Work Development

AIED technologies, integrated into digital platforms, represent a relatively new phenomenon in the field of collaborative work development. However, the expectations of how AI-based tools and applications can facilitate work development are high (Roll & Wylie, 2016; Rummel et al., 2016).

Practitioners have already noted the potential of AIED technologies for facilitation and collaborative development (Bittner, Mirbabaie, & Morana, 2021; Maity, 2019). For instance, Bittner, Mirbabaie, and Morana (2021) found that facilitators view digital assistants as highly beneficial in augmenting and assisting both collaborative development and the work of the facilitator, particularly in task- or process-oriented interventions and interaction facilitation. Similarly, Maity (2019) discovered that HR and training professionals recognize the potential benefits of AI for both supporting individual learners and enhancing interaction in personnel training within their organizations.

During the last decade, the focus of AIED technologies has shifted from supporting individual learners to enhancing social interaction, group discussions and collaboration (Dillenbourg, 2016). Studies conducted in higher education, for example, have indicated that AI-enabled feedback supports collaboration within the group, and positively affects collaborative knowledge building and group performance (Zheng, Fan, Chen, Huang, Lei Gao & Long, 2024). AI can also generate multimodal data on collaborative patterns in student groups, which is valuable for educators for tailoring support and guidance (Ouyang et al., 2023).

However, the emphasis on technological developments in AIED has also faced criticism (Dillenbourg, 2016; Wojciechowski & Korjonen-Kuusipuro, 2023) and studies have revealed that the link between AIED and educational theories is often weak (Kalakoski et al., 2021). This disconnect may hinder the implementation of AIED tools. As Rummel et al. (2016) propose, unlocking the future potential of intelligent technologies requires "work towards *a comprehensive instructional framework firmly rooted in educational theory*" (italics in original) to guide the development of AI tools for collaborative development purposes.

AI as the Facilitators' Tool

On a digital platform, technology only enhances collaborative development through transformed social practices (Ritella & Hakkarainen, 2012). The facilitators play a crucial role in creating conditions for collaborative development and interaction within the group (Clottes Heikkilä & Kurki, 2024; Evans et al., 2019; Martin, Wang, & Sadaf, 2018; Schaefer et al., 2019; 2020). AIED technologies may help here. At best, these technologies can mediate synchronous and asynchronous group interactions, collaborative problem-solving, and the construction of shared knowledge, thereby advancing development (Ritella &

Hakkarainen, 2012; Roschelle & Teasley, 1995; Stahl & Hakkarainen, 2021; Vygotsky, 1978).

Facilitators' social presence and contributions to fostering learner participation are critical for creating collaborative reflection and co-constructing shared meanings (e.g., Evans et al., 2019; Martin et al., 2018; Schaefer et al., 2020). They can employ various pedagogical methods to enhance interaction on the platform and guide and motivate the group in their developmental efforts (e.g., Martin et al., 2018). These methods include providing analytical tools and models to support the process, advancing the process by asking questions and encouraging participants to share their ideas and perspectives, clarifying and summarizing contents, and creating space for open discussion (Clottes Heikkilä & Kurki; Evans et al., 2019).

Trust is an essential precondition for the successful implementation of AI tools in facilitation (Bhimdiwala et al., 2021; Lankton, McKnight, & Tripp, 2015; Modliński & Gladden, 2021). Ejdys, Czerwińska, & Ginevičius (2024) argue that factors such as education, gender, and age influence employees' perceived trust in AI technologies. Moreover, people build their trust in each technology differently (Lankton et al., 2015). Facilitators need to view the technology as capable of assisting them to achieve their goals and providing sufficient support. The technology must also be adaptable to the diverse requirements of each group and meet the facilitators' other needs (Bhimdiwala et al., 2021).

The algorithms behind these technologies are not value neutral and are designed to highlight certain behaviors or operations (Leonardi & Treem, 2020; see also Craiuț & Iancu, 2022). However, the logic of these algorithms is often opaque to end-users: in this case, facilitators. If AI systems are not transparent, users cannot understand how different AI tools generate their outcomes, which decreases their trust in and limits their use of the tools (Brusilovsky, 2023; Qin, Li, & Yan, 2020; see also Siemon & Wolff, 2024).

In summary, previous research suggests that AI can support group interaction, participant collaboration, and facilitation in the contexts studied, but that several critical concerns, including those related to technological emphasis and trust, arise when AI is applied to support collaborative development activities in work organizations. Since the operational logic of different AI tools varies, and the tools are used in various contexts, it is crucial to evaluate each AI tool's benefits and limitations in specific situations from the user's perspective.

Our study focused on how such AI tools can help facilitators support group collaborative development. In this study we asked, RQ1: What kind of benefits and limitations do platform developers and facilitators associate with using AI tools in collaborative development? RQ2: How do AI tools support the facilitator's work?

DATA AND METHODS

The Case: A Digital Learning Platform and its AI-based Tools

Howspace, the platform under study, is a commercial digital learning platform for organizational development and facilitation that enables interaction between participants. It was built by entrepreneur educationalists to support the facilitation of collaborative processes

in organizations. The platform was launched in 2018 and is used daily by over 30 000 people in over 50 countries. The platform and its tools are constantly under further development.

Like many other digital platforms, Howspace aims to enhance collaboration between a large number of people and to overcome their temporal and spatial distances. It enables the facilitator to build a custom workspace that can be equipped with chats, polls, exams, and custom activities that enable both synchronous and asynchronous development and facilitation.

The increased ability to involve more people can result in a large amount of text-based data, i.e., discussions generated during the development processes. The volume of the text can make it difficult for the facilitator to understand and synthesize the content and main topics of the discussions. To help facilitators' work, the Howspace company has developed tools that can help in cases in which discussions and commentary abound. These tools, originally developed in 2018–2019, are based on AI technology. They rely on natural language processing, i.e., computational techniques to analyze and synthesize natural language and speech (Agarwal, 2019). Table 1 presents the AI tools in question and their purpose.

Table 1. AIrtificial Intelligence (AI) -Based Tools, their Users and Purpose]

AI tool	User	Purpose
AI Summary	Facilitator	To compile the content of a group discussion into a five-sentence long summary (including the most often-mentioned themes).
Interactive Word Cloud	Facilitator and participants	To highlight the central themes of a discussion in word cloud form. To analyze sentences and paragraphs and recognize synonyms. The original discussion on the theme can be accessed by clicking on a word of interest
Theme Cluster	Facilitator and participants	To classify discussion contents into meaningful data-driven categories. To analyze both the words and larger themes of the discussion. The original discussions associated with a category can be accessed by clicking on that category.
Sentiment Analysis	Facilitator	To categorize individual comments on a sentiment scale ranging from concerned to neutral to appreciative.

The tools enable the facilitator to, for example, classify discussions into thematic categories and condense rich and multi-voiced discussions into summaries of a few sentences. Some of these tools can also be used by the participants.

The Data

To understand the benefits and limitations of the AI tools in question, we interviewed both the platform developers (n=4) and facilitators (n=10) during the spring of 2020 and the summer of 2021. We use the term *platform developer* in a broad sense to refer to the interviewees who were involved in developing the AI tools in question. Their backgrounds varied from education and business to technical coding. The interviewed facilitators worked in six organizations in the field of research, education, and consultancy. They had different specialist roles and positions, including the facilitation of workplace development.

We interviewed the platform developers to learn about the purpose of the AI tools, how the developers intended them to be used, and the ways in which they saw that the tools could benefit collaborative development. To gain an understanding of how the AI tools were used

in practice and how they served the work of the facilitator, we interviewed nine facilitators who had practical experience of using AI tools and facilitating collaborative processes.

They were interviewed via the Teams application by six researchers (the authors and their colleagues), using a semi-structured interview method. The length of the interviews varied between 46 and 114 minutes, and the average length was 72 minutes. The interviews were audio-recorded and transcribed verbatim.

Ethical pre-evaluation and institutional permission to use the data for research purposes were obtained from the Finnish Institute of Occupational Health Ethics Committee (16th April 2020). Informed, audio-recorded consent was obtained from all the interviewees. The anonymity of the interviewees was ensured by altering any details that could enable their identification in the text and the data excerpts.

Analytical Process

We used content analysis (Silverman, 2010) to examine the platform developers' and facilitators' conceptions of the benefits and limitations of using the AI tools in the collaborative development of work. The analysis of the interview data proceeded through several reading rounds, first inductively and later informed by theory. The first and second author conducted the analysis. The research team discussed and refined the main themes and categories and their meanings until they reached consensus.

First, we read through the data carefully and selected the episodes that concerned the objectives for and consequences of using AI tools (n=100; n=53 episodes from the facilitators' interviews, n=47 episodes from the platform developers' interviews). We then categorized the selected episodes on the basis of their content. This categorization was informed by a facilitation scheme applied by Bittner et al. (2021; original by Bostrom. Anson, & Clawson, 1993), according to which facilitative acts can be classed as being targeted toward either the task, the process to accomplish the task, or the activities that affect the interaction within the group. Based on their designed function, AI tools can assist the team or the facilitator in the *task, process,* and *interaction* functions, or in the application of specific facilitation methods or techniques (Bittner et al., 2021). Using this interpretative framework, we classified the episodes into four use categories: assistance related to 1) single tasks, 2) participation, 3) the developmental process, or 4) interaction on the learning platform. We further observed that the interviewees associated both benefits and limitations with these different uses and included them in the analysis. Table 2 presents examples of this categorization. The categories were not exclusive, and some episodes were placed in more than one category.

Table 2. Example of Categorization

Use of Alartificial intelligence (AI) in	Platform developers' conceptions	Facilitator's conceptions
Single tasks	*About the word cloud…gives you access to information sources and the right context…truly a tool that speeds up compilation work.*	*Regardless of the size of the group and how long-windedly things are being told…we get a word cloud. From there someone says... look up self-directedness...and from the chat we get all the comments that mentioned it.*
Interaction	*...can be accessed by the participants, and thus also supports, you know, dialogicity... the facilitator can... what has been discussed about this word or around this theme... [make] sense of the conversation*	*you can connect to the conversation in your own time and see what went on there...you could, you know, just find the things that interest you and go on from there.*

Through the categorization process, we found that the interaction between the AI and the facilitator was an important, cross-cutting theme in the data. Thus, we conducted a supplementary analysis on episodes that concerned "the AI as a facilitator's tool" (n=97, n=56 episodes from the facilitators' interviews, n=41 episodes from the platform developers' interviews). We further observed that the interviewees' conceptions of the theme were diverse and partly contradictory. Therefore, we included the tensions between the expectations and practice in the analysis.

RESULTS

The Benefits and Limitations of AI tools

The benefits associated with the four AI tools were related to four functions: 1) Task assistant, 2) Participation assistant, 3) Process assistant, and 4) Interaction assistant.

First, the AI tools were useful as **task assistants**. This means that they helped the facilitator summarize, visualize, and categorize task-based discussions. According to the interviewees, the main value of the tools was their ability to summarize long discussions easily and quickly during the developmental process. However, this added value of the AI tools was limited to small groups, when the facilitator could easily do the summaries and categorizations. The interviewees also saw it as a benefit that some of the AI tools enabled access to the original comments when keywords and categorizations were clicked on. This helped the participants understand and follow the discussions in each category.

Second, the AI tools worked as **participation assistants**. They could be used as a means to support group members' participation in the developmental process. The interviewed facilitators and platform developers expected the AI tools to promote inclusive participation, even when a group was large. This was because they made the contributions of each participant visible, even in multi-voiced discussions. One of the interviewed facilitators described how AI compilation (AI output) could be used as a tool to crystallize the "*group opinion"*. Thus, the AI tools helped the facilitators discover the most important themes in the

discussion. The interviewees also pointed out that AI created at least *"a feeling that everyone's voice had been important"* and that their contribution had been noticed.

Third, the AI tools served **as process assistants** as they helped the facilitators strengthen the continuity of the development process. One platform developer claimed that the AI compilations should not be interpreted as a completely accurate summary of the discussion, but should be approached as a stimulus for continuing the process. The interviewees claimed that AI output could highlight central or interesting themes in the discussion. The facilitator could, for example, direct further discussions toward these themes. This may help the group achieve the goals of the development process. Furthermore, the platform developers also saw the potential for more profound outcomes. For example, one interviewee suggested that these AI-enhanced assignments could have a major impact on the quality of participants' thoughts and discussions, and in the long run, even on organizational change.

Fourth, the AI tools could potentially act as **interaction assistants**: the AI summaries and categorizations provided a stimulus for additional discussions. The interview data showed that AI tools could assist dialogue in two ways. First, the "*imperfect"* AI compilations could generate topically rich discussions on some important viewpoints, or bring new nuances into a group's discussion. Second, the AI-based categorizations enabled participants to choose the themes in which were interested and to join the relevant discussions. This offered the participants the opportunity to deepen their understanding of the themes in question. The platform developers further suggested that in addition to promoting dialogue, AI tools could make sense of large volumes of dialogue, which is helpful especially with larger groups. This could also help participants contribute to the dialogue. Table 3. summarizes these benefits and presents a data example of each function.

Table 3. Functions and Benefits of Artificial Intelligence (AI) in Collaborative Development

Function	Benefits	Data example
Task assistant	Summarization, visualization, and categorization of discussions	*F2: "With large organizations I use these analytic [AI]tools… It's crucial to get a picture of what we think and where we are now."*
Participation assistant	Supports the equality of contributions; everyone's voice is heard. Supports forming a common vision (only platform developers)	*F 6: "Everyone wrote down their ideas, for two or three minutes, then we used 'likes'… After I showed the [AI] summary, it was easy for the participants to keep nodding – yes, that's what we talked about."*
Process assistant	Supports the continuity of the process. Stimulus for additional discussions.	*PD 2: "It's like you don't think that the summary produced by AI is the right solution, rather let the AI make some kind of summary from the masses of text and then people can continue on the basis of that."*
Interaction assistant	Categorizations stimulate dialogue e.g., enable contributions to interesting themes. Supports sense-making (only platform developers).	*PD 1: [Lots of] people have been invited to the debate, and there will be hundreds of pages of data… what would make it easier to understand what issues are being discussed in the debate? So, help to help the dialogue itself, but also to help our understanding of it, that of both the participants and the facilitators.*

The table shows that the platform developers presented a larger repertory of the AI tools' practical applications than the facilitators, including using them to promote a common vision and sense-making.

The interviewees also identified some limitations of AI tools, which were mainly related to the operational logic of AI. First, the accuracy of AI outputs varied, and AI did not recognize all the nuances in comments. Non-topic-related comments may also feature in summaries, and not all the similarities between the comments that AI recognized corresponded with human logic. Secondly, the studied tools used natural language processing to analyze text-based data, and this may have limited inclusive participation, as writing may not be the preferred communication method of all the participants. Third, as the use of tools was limited to single tasks, they could not capture the longitudinal development of the discussion topics, nor the development in individual participants' responses.

AI as the Facilitators' Tool: Trust and Usability

As presented above, AI tools can support collaborative activities and discussion within groups and facilitate the continuity of the collaborative development process. However, from the facilitators' point of view, the use of AI was also sometimes problematic.

According to the platform developers, the primary driver for developing AI tools has been the need to find ways to assist facilitators in their work. The tools are intended to reduce the amount of facilitation work and to help facilitators analyze and summarize discussions on the platform and use this knowledge to serve the development process. The platform developers highlighted that AI "*doesn't replace anyone: neither trainers nor facilitators, but it helps their work".* They suggested that the facilitators benefitted from the AI tools the most, when they *"experimented"* and *"applied"* the AI tools and *"reflected on"* their outputs with the group to support shared development. The platform saw the AI–human interplay as complementary and unproblematic.

For the facilitators, in turn, the human–AI interplay was more complicated. They raised two major challenges. The first was related to their own competences in using the AI tools. The facilitators pointed out that the AI compilations may turn out to be irrelevant if they "*just put out a question and ask people to answer it"* without any deeper consideration or design idea. Thus, designing "*AI-friendly tasks"*, i.e., tasks that correspond with the AI logic, requires new competences of the facilitator.

The second challenge concerned the usability of AI tools and the facilitators' confidence in the algorithm programmed into these tools. As the facilitators did not always trust the AI compilations, they took time to make themselves familiar with the original contents: *"I check [the discussions] at least few times to see if I agree".* This extra work obviously contradicts the platform developers' original idea of reducing the facilitators' work. In the interviews, the facilitators recurrently questioned their trust in the algorithm and AI outputs, as exemplified in the following data extract.

> *F 10: The biggest thing is always that the person who uses it [AI] has to trust it. When you don't know, and I've interviewed Howspace people many times about it, asked them to tell me how it [AI] works…, and I've had the vector space in the background explained to me. And then you're like, damn it, as you're not able to understand it,*

> *how it does it. And then there's also the fact that I don't quite know where this is coming from…could it be some form of interaction with the AI? I'd like to understand interactional processes and how new ideas are built within them. So, of course, I'd like to understand how artificial intelligence builds them from this human reality.*

In the excerpt, the facilitator emphasizes that one of the most important requirements is confidence in the AI compilations. They find it difficult if they do not understand the logic through which the AI tools form their outputs. The facilitator describes how, in their quest to understand the operational logic of the AI tools, they had contacted the platform developers to try to extract the information, but to no avail. The facilitator above emphasizes the need for transparency in this regard; so that the AI compilations are not just be something that appears from nowhere. For the facilitators, confidence in the AI compilations was a prerequisite for presenting them to participants. Regardless of whether the compilation was created by AI or not, what was relevant for the facilitators was that all the central aspects of the conversation were taken into account.

To sum up, the tensions related to the utilization of AI tools in collaborative development are intertwined with the facilitators' understanding of the logic of the algorithm (see Figure 1).

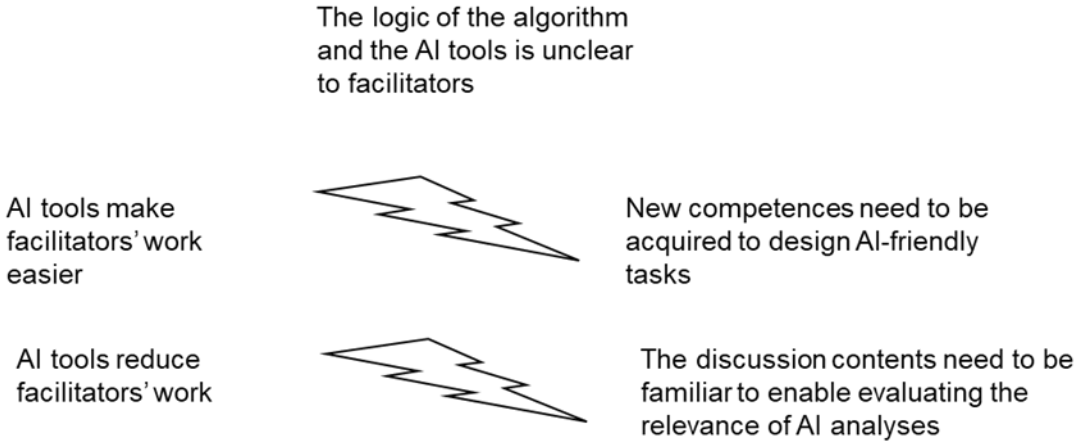

Figure 1. Utilization of artificial intelligence (AI) -based tools; tensions between expectations and practice

First, AI tools are intended to support the facilitator by reducing and easing their work. However, for the facilitators, the challenge was that utilizing AI tools requires acquiring new knowledge and pedagogical competences. The facilitators have to learn how to formulate AI-friendly tasks so that the participants' contributions correspond with the logic of the AI, enabling it to produce relevant outputs from them. They must also find ways to utilize these outputs in a pedagogically meaningful way.

Second, as the logic of the algorithm is unclear to the facilitators, they are often unsure about the *accuracy* of the AI output. To be able to assess the relevance and validity of the AI output, the facilitators need to familiarize themselves with the contents of the original

discussion in question. As this manual reviewing takes time, it is worth questioning whether the AI tools actually reduce the work of the facilitator or, in some cases, possibly increase it.

DISCUSSION

AI and AI-based tools are increasingly being used in organizations as a means to support collaborative development on digital platforms. The aim of this study was to explore the benefits and limitations of using AI tools when facilitating collaborative development and examine how the tools impact the (human) facilitator's work.

The study showed that the benefits and limitations of using AI tools for collaborative development were related to four interconnected functions – AI as a task assistant, a participation assistant, a process assistant, and an interaction assistant. The perceived utility of the AI tools for the different functions varied. With regard to the task and participant assistant functions, interviewees emphasized how the main benefit of the AI tools was their ability to comprehensively summarize or visualize task-based discussions. They felt that the AI outcome can, at best, crystallize the group's opinion and help create a sense that everyone is participating equally in the process. The main limitation associated with the tools was their varying ability to obtain all the relevant content and detect the nuances of the discussions. The facilitators felt that the variance in the accuracy of the AI compilations reduced the tools' value. Regarding the process and interaction assistant functions, the perceptions of AI and its benefits differed from those regarding the two other functions. When the facilitators used the AI outputs as a stimulus for the development process and interaction within the group, they regarded how well the tools captured or summarized the discussion as less important. Instead, they saw the tools' value as being in their ability to stimulate further discussions. Therefore, when used in combination with other facilitative acts or further assignments (see Dillenbourg, 2016), the imperfect compilations were perceived as being able to generate critical, reflective group discussions or promote sense-making within the group in the way envisaged by the platform developers.

The interviews took place about two years after the AI tools in question were first launched. The interviewed facilitators can be characterized as early adopters of a novel technology (see Rogers,1962) who were, at the time of the interviews, weighing the tools' advantages and disadvantages on the basis of their still limited but growing experience of applying them in different situations. At this stage of adapting a novel technology, trust is integral in shaping the users' perceptions of the technology's usefulness (Bhimdiwala et al 2021; Ejdys et al., 2024; Lankton et al., 2015; Modliński & Gladden, 2021). Our results showed that the facilitators did not fully trust the accuracy of the AI outputs, and that this hindered their use. One of the main purposes for developing the AI tools, as described by the developers, was to ease and reduce the amount of facilitators' work (see also Wojciechowski & Korjonen-Kuusipuro, 2023). However, the uncertainty about the way in which the tools form their outputs, and the distrust that this generated, meant that the facilitators felt the need to assess their accuracy by familiarizing themselves with the original content. This, together with the need to improve their own competencies in utilizing the tools, may in fact have increased the facilitators' workload. This perceived uncertainty is linked to the fact that the logic of the algorithm behind the AI tools is "black-boxed", meaning that it is hidden from, or

unclear, to the user (Qin et al., 2020). This presented a problem for the facilitators, particularly initially, because they felt that to fully utilize the tools, they needed to understand how the outputs were formed and conclusions reached (Leonardi & Treem, 2020; Qin et al., 2020). However, when the facilitators had accumulated more experience of the different ways in which the tools could be applied to serve the group's needs (Bhimdiwala et al 2021), they learned to use them in ways and in situations in which the issue of accuracy, and therefore also trust, was not central to the facilitation process. In such situations, the AI tools could be seen as complementing human facilitation (Dillenbourg, 2016). The facilitators' concerns about the AI tools' transparency stemmed from the fact that programmers control data visibility through algorithmic ordering (Leonardi & Treem, 2020). However, views related to this issue were completely absent in the developers' interviews, which raised concerns about their awareness of and willingness to discuss such issues publicly. This is worrying, as full transparency requires user control over some parameters to ensure visibility of their impact on the results (Brusilovsky, 2023).

When it comes to the potential of AI tools, as intelligent technologies, to support collaborative processes, there is particular interest in whether and how AI tools can do this by stimulating group interactions, such as expressing critical viewpoints, solving problems, and creating new knowledge (Engeström, 2015; Roschelle & Teasley, 1995). On the studied platform, the AI tools were at least somewhat effective in this regard, but they required human guidance to have an impact, emphasizing the importance of the facilitators' role and pedagogical knowledge (Ritella & Hakkarainen, 2012). To function as intended, the use of these tools must be designed to support each process's goals and to require participant data, in this case the participants' comments on the platform. This in turn requires the facilitators to learn to formulate assignments that encourage participants to contribute to the discussions on the platform, which can then enhance the interaction that is beneficial for collaborative development (Ritella & Hakkarainen, 2012; Yoon et al., 2020).

Today's rapid development of learning technologies offers new opportunities for digitally mediated collaborative development. AI technologies, though primarily designed for other purposes, can also be beneficial, especially for experienced facilitators (see Johnson, 2023; Mhlanga, 2023). For instance, generative AI, such as ChatGPT, can stimulate analytical thinking and teamwork among students, for example, provided that it does not replace teacher-student interaction (Mhlanga, 2023). However (the still) limited accuracy, transparency, and biases may restrict its usage. Platform developers should explain AI algorithms' logic and values to build facilitators' trust and ensure their suitability for their specific needs (Bhimdiwala et al., 2021; Lankton et al., 2015). Collaboration between researchers, developers, and pedagogical specialists is crucial for designing effective AIED technologies (Stahl & Hakkarainen, 2021). Integrating technological development into educational theories and practices can help AI tools support facilitators in complex tasks, allowing them to focus on more important pedagogical aspects (Rummel et al., 2016; Stahl & Hakkarainen, 2021; Brusilovsky, 2023).

Although the results of this study are promising, more AIED research is needed on collaborative work development. Our study is a snapshot of platform developers' and facilitators' conceptions of the benefits and limitations of using a specific AI tool on a specific platform created for synchronous and asynchronous interaction and development. As AI is developing so rapidly, and the features of the studied AI tools are under continuous

development, the conceptions of their benefits and limitations are also likely to change over time. The central limitation of this study was that it did not include the viewpoints of the participants, i.e., the people who took part in the collaborative development. Furthermore, the use of AI for the purpose of collaborative development is something that cannot be fully captured by merely studying people's conceptions: This would require combining various approaches, methods, and materials (Silverman, 2010). To strengthen our findings, the data derived from the AI-enhanced collaborative development activities on the platforms also need to be analyzed. For instance, it would be valuable to compare different AI-enhanced developmental interventions and to study how pedagogical solutions and different learning platforms affect development processes and outcomes.

CONCLUSIONS

Digital platforms enhanced by AIED tools are being increasingly used to facilitate the collaborative development of work. This study shows that AI tools can be utilized as task-assistant, participation-assistant, process-assistant, and interaction-assistant functions. Through these functions, and in combination with compatible facilitative actions, AI tools have the potential to mediate collaborative development on digital platforms. However, because the operational logic of the AI tools was unclear and opaque to the facilitators, they were not able to utilize the tools' to their full pedagogical potential. This suggests that platform developers should clarify the logic of the algorithms, make visible the mechanisms through which the AI tools form their outputs, and offer users at least some control over the algorithms.

IMPLICATIONS FOR THEORY AND APPLICATIONS

This study expands the scope of AIED research to work development and examines AI–human collaboration, specifically, the potential of AI-based tools to support the facilitation of collaborative development processes. It highlights that AI tools do not generate developmental actions as such, but that they may help facilitators create conditions for collaborative development. By identifying four functions of AI tools (i.e., task assistant, participant assistant, process assistant, and interaction assistant), the study helps facilitators reflect on the ways in which they can utilize these specific tools in their own work. The study also identified some limitations to using AI-based tools, such as the need for facilitators to acquire competences in utilizing AI outputs in a pedagogically meaningful way. Platform developers, on the other hand, should be more aware of the practical challenges that facilitators face when using the tools. The study suggests that to increase the usability of AI tools, platform developers should improve the transparency of their algorithms.

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Capturing patient voices: A focus group-based study unveiling the potential of AI in medical diagnosis

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Abstract: *Purpose: This study examines patients' perspectives on the integration of artificial intelligence (AI) in radiology through focus groups, aiming to identify the main issues and areas for improvement. It is part of a larger research project that employs various methodologies to explore the views of both patients and radiologists regarding AI tools. Methods: We conducted two focus groups using a narrative story and vignettes: one with patients who self-assessed as AI experts and the other with non-AI experts. Results: The focus groups revealed diverse opinions on AI use in diagnostics, focusing on six main topics: acceptance, concerns, communication between radiologists and patients, explainability of AI, medical records, and emotional aspects. Conclusions: The findings underscore the importance of developing patient-centric AI solutions to build trust in AI-assisted diagnostic tools, considering emotional and communicational aspects and addressing both physician and patient concerns to facilitate smoother integration of AI in radiology.*

Keywords: *Artificial Intelligence, medical diagnosis, patient perspective, focus group, User Experience, Interaction Design.*

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INTRODUCTION

The integration of artificial intelligence (AI) technologies in medical practice has the potential to revolutionize the healthcare sector. AI has the ability to analyze vast amounts and various forms of data, thereby supporting the needs of medicine in ways that were previously unimaginable (Davenport & Kalakota, 2019; Malik et al., 2019; Yu et al., 2018). With rapid advances in computer processing and the capabilities of artificial intelligence-based systems, there is potential for significant improvement in the accuracy and efficiency of diagnosis and treatment in various specialties (Kulkarni et al., 2020).

Among these, imaging is one of the specialties that would most benefit from the potential of AI thanks to the large amount of data available (Hosny et al., 2018). One of the reasons behind AI's growth in medical imaging is the need for better effectiveness and efficiency in patient care. The amount of imaging data is growing much faster than the number of trained professionals to read it. As a result, radiologists are dealing with huge workloads which can lead to mistakes (Fitzgerald, 2001). AI can assist radiologists by, for example, providing pre-reconstructed images (Zhu et al., 2018) highlighting important features (D'Amico et al., 2018; Secchi et al., 2022), and prioritizing the most urgent examinations (Topff et al., 2023), thus facilitating workflow (European Society of Radiology, 2019). In this way, integrating AI into imaging allows processes to become more efficient, reduce errors (Hosny et al., 2018), and save time that can be used to improve doctor-patient interactions and facilitate a more patient-centric approach (Gampala et al., 2020; Topol et al., 2019).

Despite this, the integration of AI into healthcare systems has not been without controversy and research has raised concerns over legal lacunae, ethical issues, privacy, and accountability questions (Lekadir et al., 2022). These factors may contribute to undermining people's confidence in these technologies and consequently restrain their implementation in daily clinical practice. The large-scale deployment of AI will inevitably affect the physician-patient relationship in ways that are not easy to predict (Greco et al., 2022; Sauerbrei et al., 2023). The interaction between physicians and patients, characterized by empathy and compassion, is considered fundamental for patient engagement. This trust-based relationship has the potential to enhance patient satisfaction and adherence to prescribed treatments. In this context, the use of AI could introduce communication barriers and diminish human social interaction, thereby undermining the empathetic aspect of AI (Esmaeilzadeh et al., 2021).

In order to ensure the successful integration and adoption of AI technologies in healthcare, it is crucial to consider the perspectives and opinions of all stakeholders: physicians and patients first and foremost (Li et al., 2022; Mousa et al., 2023; Vo et al., 2023; Kang et al., 2023). In particular, patients play a central role in the healthcare system and their views and trust are vital in shaping the future of medical practice. Other studies have explored patients' opinions on the adoption of specific AI tools in medical practices (Ho et al., 2023; Hummel et al., 2024; Schaarup, et al., 2023), ranging from specific geographical areas (i.e., Central Denmark, Japan) to specific sectors of healthcare (i.e., people living with diabetes, emotional AI technologies). In general, in the above mentioned studies, positive attitudes were observed toward the use of AI in the medical field, recognizing its benefits for improving patient care, research, and education, highlighting that AI could potentially be used to create social value in medicine, provided it doesn't replace emotional and empathetic interactions. In the context of a specific mapping of the Italian territory and in the field of

diagnostics and imaging, we decided to employ various methodologies to question the stakeholders involved. This work is part of a research project that aims to explore the opinions and potential concerns of patients and physicians regarding the integration of AI technology in the diagnostic field. The goal is to understand how the use of AI is perceived and, if the current perception is not positive or can be improved, to derive design directions to enhance this sensitive interaction. This includes understanding how to increase trust in these tools to foster their adoption. To achieve this purpose, we conducted quantitative (large-scale questionnaires) and qualitative analyses (focus group) with the aim of mapping the perceptions of radiologists and patients regarding the use of AI in diagnostic settings, some of them already published (Ibba et al., 2023; Cè et al., 2024).

In particular, in this study, we present two focus group sessions with patients, engaging in detailed discussions on various aspects of AI implementation in diagnostic settings. Topics include the relationship between patients and AI diagnostic tools, the role radiologists play for patients when adopting AI instruments, and more. Our aim was to corroborate the results obtained from a previous questionnaire administered to 2119 patients, which showed a positive view of the potential benefits AI can bring to medical practice, especially in radiology. Patients appreciate the use of AI for more accurate diagnoses but emphasize the importance of the radiologist's supervision. The role of the radiologist remains pivotal and becomes even more important in the interpretation and communication of AI outcomes (Ibba et al., 2023). The innovative focus group methodology aimed to use narrative techniques to empathize with patients in situations where AI diagnostic instruments were present. The scenarios presented to the users were developed by reflecting on current and future use contexts to evaluate the impact of a progressive shift away from medical intermediation and the introduction of a direct relationship between AI and the patient. This approach sought to capture emotional and contextual nuances that might have been missed with the large-scale questionnaire.

The rest of the article is structured as follows. The next section presents the materials and methods used in conducting the two focus groups, gathering patients' opinions and feedback, and highlighting how the data were analyzed. The results of the two focus groups are illustrated in Section "Results" and discussed in Section "Discussion". Finally, final observations and directions for future work are identified in Section "Conclusions and Future Work".

MATERIALS AND METHODS

We conducted two online focus groups with 15 patients in the field of radiology to understand their perception of the use of AI in diagnostic medicine. We chose to use focus groups as the next step after a preliminary quantitative investigation (Ibba et al., 2023) because they allow researchers to uncover unexpected issues that cannot be identified through structured surveys. Despite the limited number of participants, typically ranging from 6 to 8, which may limit the generalization of the research, focus groups are particularly suitable for collecting qualitative data from users (Wilkinson, 1998). The approach is based on open-ended questions to explore users' attitudes, feelings, and beliefs, but also includes a series of designed questions to explore new feedback and generate new ideas (Mazza & Berre, 2007; Rabiee, 2004).

The participants were recruited from patients who voluntarily subscribed to the newsletter of CDI Centro Diagnostico Italiano, requesting voluntary interest in participating in an online focus group on AI in medicine. Interested participants responded to the email (128 responses), and a short questionnaire was sent to them to profile them based on age, gender, education level, and self-assessment of AI knowledge. They were also asked to propose two dates to join the focus groups.

The selected participants were divided into two focus groups: one group consisted of participants with a medium-high level of AI knowledge, while keeping the other three variables equally distributed, and another group consisted of patients with a self-assessed medium-low level of AI knowledge.

The choice to keep the two groups separated based on self-assessed AI knowledge level was made for two reasons: (i) to avoid the potential situation where individuals with less expertise in the topic might feel inadequate and participate less actively in the focus group, and (ii) to compare the results of the two focus groups to assess any differences, using AI knowledge level as a variable.

Each participant read and signed the privacy information form to participate. Each focus group lasted approximately 2 hours on the Google Meet platform and was moderated by one of the authors, while another author took notes using the Miro tool, which was also used to design the different phases of the focus group. Additionally, video and audio recording were used to enable subsequent review and analysis of the discussion.

Focus Group Design

Both focus groups followed the same structure to address the following research questions: (i) What is the attitude of patients toward doctors using AI? (ii) How much do patients trust medical results derived from AI? (iii) How is the physician's role perceived in the communication between AI and patients? (iv) What do patients want to understand about the functioning of AI tools? (v) How can the results of AI-assisted analyses be communicated in the clearest possible way to patients?

To facilitate a discussion around these five research questions, we decided to develop a scenario divided into five steps of a single story, utilizing visual support of vignettes (Fig.1) to help participants better empathize with the proposed situations and provide responses that closely align with their own experiences. For each step, the moderator provided an introduction and invited each participant to respond individually using Google Forms within 5 minutes.

Subsequently, the moderator initiated a guided discussion between all participants.

This approach, which involved collecting individual responses first and then engaging in discussion, allowed us to (i) obtain input from all participants, as some may be less inclined to express themselves openly, and (ii) have pre-discussion opinions that could potentially change during the discussion.

After a brief introduction to contextualize the focus group and break the ice with the participants, they briefly introduced themselves to each other. The moderator then posed a series of questions to the attendees in order to engage them in a broad conversation and encourage them to start conversing with one another:

- What are your thoughts on Artificial Intelligence in general?

- What are the advantages and disadvantages of AI for you?
- In the medical and diagnostic field, have you ever interacted with AI?
- Have you ever read or looked through your medical records? What is their purpose?

Following this initial phase, the focus group proceeded with the five steps as follows, asking for their reactions if they were in the protagonist's shoes, Mr. Paolo Rossi:

1. Mr. Paolo Rossi, after experiencing a series of episodes of forgetting what he did, visits a doctor and undergoes four different examinations. After analyzing the results of these examinations, the doctor concludes that the likelihood of a neurodegenerative disease is low. However, there is a possibility of using AI for an additional opinion. What would you do if you were Paolo Rossi?
2. Paolo Rossi decided to use AI. The diagnosis formulated by AI is a "medium-high risk of developing a neurodegenerative disease", suggesting further investigations through a specific type of exam. However, the attending physician does not consider the AI diagnosis reliable and prescribes a different type of exam from the one proposed by AI. The doctor tells Paolo Rossi that, in their opinion, AI tools are not yet reliable given technological advancements. Paolo Rossi can choose to trust the doctor's words or present the AI diagnosis report to another specialist. What would you do if you were Paolo Rossi?
3. Paolo Rossi decides to consult another specialist. After thorough research, he approaches a doctor who extensively uses AI as a support and is considered an expert in the field. Dr. Bianchi reviews Mr. Rossi's medical records and believes that the investigation conducted by the first hospital using AI is not particularly reliable due to outdated data and analysis tools. Dr. Bianchi asks Mr. Rossi to undergo a new examination using a new technology based on different AI algorithms that Dr. Bianchi trusts. The result of the new examination is the same as the previous one. Would you prefer Dr. Bianchi to explain the details of AI, or is it sufficient for you to know that Dr. Bianchi trusts the result?
4. Mr. Rossi wants to better understand why Dr. Bianchi trusted AI while the first doctor did not. He asks Dr. Bianchi for explanations. What questions would you ask to better understand how AI functions?
5. In this phase, a hypothetical report (Fig.2), specifically adapted from those currently used by doctors, was shown to assess (i) what was clear and (ii) what was unclear to the patient, (iii) what they would prefer to read and how, and (iv) how they felt emotionally while reading such a report.

Data analysis

The audio recording of the focus group was transcribed for coding: three authors analyzed the transcripts, Google Forms responses and notes taken during the focus group. The transcripts and Google Forms were handled with Atlas.ti software (Version 23.2.0 (4305)), following the constant comparison analysis method. We chose to use this method in order to test the frequency and recurrence of the same themes in the two different focus groups (Onwuegbuzie et al, 2009). Two of the authors worked independently, using, during the first phase, the open coding technique to assign relative codes to each intervention. Then, during the second phase (axial coding), the authors grouped data into categories. Finally, in the final phase (selective

coding), the researchers developed more themes that expressed the content of each of the groups. At the end of each phase, the authors compared with each other, discussing and resolving disagreements. New codes that emerged during these phases were also discussed to determine whether they should be retained, merged or eliminated. The authors then arrived at 6 themes, which can also be traced back to the 5 phases of the focus group (the last two emerged in the last phase): (i) acceptance of AI in medicine, (ii) concerns, (iii) communication between patient, physician and AI, (iv) explainability of AI, (v) medical records and referrals, and (vi) emotional aspects. Each of these themes brings together various categories: for example, the theme of concerns includes "concern of the contrast between doctor's opinion and AI", "concerns about the doctor-patient trust relationship", "concerns about doctor's preparation about AI", "concerns related to privacy", "concerns related to informed consent" and "concerns related to AI regulation". This step was followed by identifying representative quotes to support the statements. We also decided to maintain a comparison between how the various issues were raised in the two different groups.

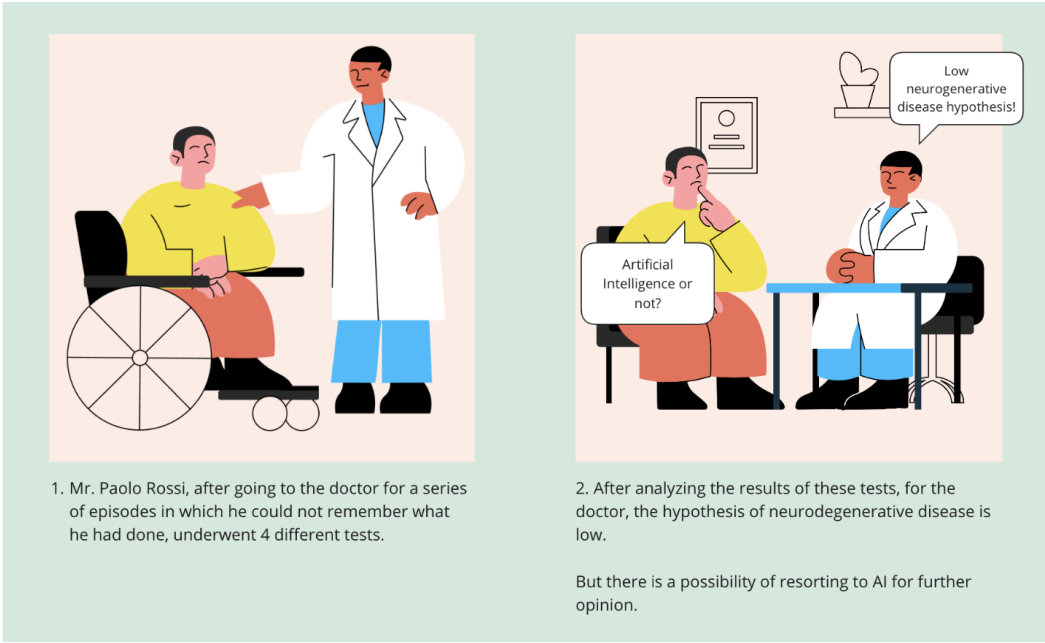

Figure 1. Example of a graphical scenario presented to the patients: this particular panel illustrates the first step of the story.

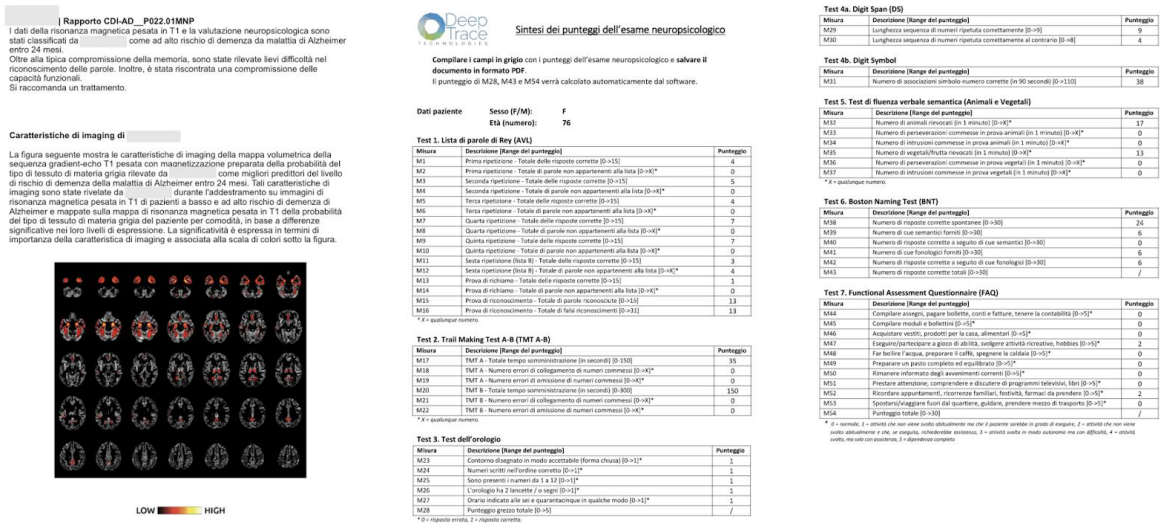

Figure 2. Report presented to the patients.

RESULTS

The two focus groups were conducted in December 2022 and April 2023. The 15 participants selected were then divided into two groups: experts and non-experts. The first focus group was conducted with 8 patients who self-rated themselves as medium-experts (A). The second one, on the other hand, was conducted with 7 patients who rated themselves as having little or no expertise in AI (B). The 15 selected participants are distributed as in Tables 1 and 2.

Although the two focus groups involved people with different knowledge of AI, themes emerged in both groups, even if with slightly different frequencies. Below, we will go on to analyze the discourses that emerged for each theme.

Table 1. Group A participants, also referred to as 'experts" (self-reported a medium to high level of AI knowledge).

ID	Age	Gender	Level of education	AI experience (self judgment 1-5)
A1	50-59	Male	University or similar	4
A2	40-49	Male	High school diploma	4
A3	40-49	Male	University or similar	4
A4	> 60	Male	Post-graduate specialization	5
A5	50-59	Female	High school diploma	3
A6	30-39	Female	University or similar	4
A7	> 60	Female	High school diploma	3
A8	> 60	Male	Post-graduate specialization	4

Table 2. Group B participants, also referred to as 'non-experts" (self-reported having little to no knowledge of AI).

ID	Age	Gender	Level of education	AI experience (self judgment 1-5)
B1	> 60	Male	High school diploma	2
B2	> 60	Male	High school diploma	3
B3	50-59	Female	University or similar	3
B4	50-59	Female	High school diploma	1
B5	50-59	Female	University or similar	1
B6	> 60	Female	University or similar	2
B7	> 60	Male	High school diploma	3

Acceptance of AI in medicine

In general, all participants were in favor of the use of AI tools in the medical field (the code "favorable" emerged 15 times) or at least its use was viewed in a "positive" way (5 times), as it was acknowledged that it "supports the work of the doctor" (6 times), especially "in the diagnostic field" (2 times) and "facilitates and speeds up data analysis" (2 times): "*I would like my doctor to be supported in something that humans have a hard time doing, which is to see a lot of data. The problem with humans is that they see everything through their experience, which, however great, is limited*" (A2). Both groups showed the same distribution, despite different levels of AI knowledge (A = 7 times, B = 8 times).

Concerns

Especially during the second step, but also at other times during the focus group, several concerns related to the use of AI in the medical field emerged. The first concern raised, which also emerged due to the structuring of the step itself, is precisely about the possible "clash between the doctor's opinion and AI" (10 times), most prevalent in the non-expert group (A = 3 times, B = 7 times), which causes "distrust in the doctor due to the inconsistency" of wanting to use AI but then deviating (2 times) and triggers the fear that the use of AI could "create distrust in the doctor" (1 time). The concern that adversarial situations might arise is based on the more specific fear of "the physician's inexperience with AI" (4 times), a concern that opens up comments that it is often the patients themselves who "inquire about the physician's CV" (2 times), about the type of technologies - more or less advanced - that are used by the center in which the physician operates (3 times). A3 states: "*I am afraid of scenarios where AI and doctor's views are conflicting if the doctor does not have full knowledge and awareness of what AI is and how it works, because humans do not like to be contradicted. The problem arises when physicians and AI disagree*".

Other concerns raised included those pertaining to "privacy" (3 times) and "informed consent to the use of AI tools" (4 times): these codes were noted only in the A focus group. Regarding informed consent, A6 claimed that they were not interested in whether the doctor used AI, while the other three claimed that it was as important to them as knowing the use of their data, coded as "privacy".

One theme that emerged, however, only in the B group was "concerns related to AI regulation" (5 times). Various codes, which emerged during the beginning of the discussion related to the third step and, in particular, to the consideration that there are more or less up-to-date AI tools, came under this category. One participant (B4) was surprised at the information that AI does not mean a single entity, while three others said that their choice of which center to go to depends on the technological advancement of the tools used in each field: *"When I have to do some exams I also decide which center to go to depending on the tools I know they use: more than the doctor, for exams that have become routine I have the centers I trust, whose technological updates I follow. For example, for a CT scan I go to X, but for mammography I go to Y"*. From these considerations, the importance of having a single regulation for AI tools was raised (4 times), imagining that there should be minimum requirements on the update and performance of AI tools used in medicine. The democratization of the dissemination and quality of AI tools in the medical field has also been associated with an economic problem of patients (1 time), as not everyone can afford to go to private and centers of excellence in the field of AI tools, but also territorial (2 times), referring to the disparity in public health.

Communication between patient, physician and AI

During the second and third steps of Paolo Rossi's story, participants focused on communication between patient, physician and AI, dwelling on the role of the physician in this three-way relationship. As already shown in the "concerns" theme, the physician's role is not secondary. The mediation of the physician was considered crucial (21 times), mainly among experts (A = 12 times, B = 9 times), not only in assessing the reliability of AI results (7 times), which is considered indispensable in making diagnoses (4 times), but also in reassuring and conveying confidence to the patient (5 times) in communicating the results: *"In my opinion, the AI must be available to the physician before making his diagnosis, because for the patient to learn about the AI outcome in contexts of major diseases could be a boomerang: unfortunately, we patients lack medical knowledge and need confidence in dealing with diseases. And it is the doctor who needs to convey this confidence, and not AI, which should instead be a tool for the doctor to strengthen his knowledge and diagnosis in order to propose the most appropriate treatment"* (A7).

Trust in AI is often linked to the trust patients have in their physicians, which was mentioned 8 times during our interviews. Additionally, trust in AI is influenced by factors such as the physician's age and their familiarity with technology (3 times). Furthermore, the physician's own trust in AI (5 times), plays a significant role. Some patients even probed the physician's stance on AI with preliminary questions (mentioned 3 times) to gauge their comfort with this technology. In cases where they found a misalignment, 2 patients mentioned considering switching to a more AI-oriented physician. Direct communication between AI and patient is thus decisively rejected (19 times), with more conviction in the A group (A = 14 times, B = 5 times). The reasons are various: they need to be reassured in the case of serious illness (7 times), communication in everyday life with generic AI tools is considered already complex and frustrating, so they fear even more such a complex field as medicine (4 times). They feel the need for subjectivity and personalization during the dialogue with the doctor (3 times), as well as being aware that they need someone to guide

them in understanding the results, since the medical field is not easily interpreted (3 times). A6 says: *"The results given by AI tools should be accessible only to the physician, as not only do we need a figure to contextualize them, but also to avoid creating confusion for the patient who is already in a moment of high pressure, crisis, and anxiety...when it comes to important diseases there is a need to trust the physician and for him to reassure us"*.

Explainability of AI

The explainability of AI was one of the themes deliberately introduced through Step 4, but during the B focus group emerged spontaneously already during Step 2, anticipating the flow. Thus, it seems important for patients to understand how AI tools work at the time the physician introduces them since this is the only way they can trust (17 times), although others (3 participants) prefer to have information about the diagnosis and treatment more than how it got there, and one A group participant fears that it would only confuse the patient. Most of the interventions in favor of understanding how AI tools work stick to low-tech explanations (14 times, of which B = 10 times): they want to know the reasons why the physician defines one AI as more reliable than another (4 times), whether it is related to the amount of data analyzed (3 times), the exclusion or inclusion of certain case histories similar to their own (2 times), how up-to-date it is (4 times), how reliable it is (1 time). In the A group, on the other hand, three participants would like precise and technical information about how the AI tools used work: they would like to see statistics (2 times), know the type of software (2 times), know how it was tested (1 time), know the depth of scan (1 time), be informed about neural networks (1 time) and the level of database sharing (1 time).

Medical records and referrals

The last step of Paolo Rossi's story required participants to analyze a medical record and generate questions about it, with a focus also on the emotional aspect (the results of which we will present later). Preliminary questions about the medical record carried out during ice-breaking, revealed that it is not used much by patients (10 times), as it is considered unclear (3 times), inconsistent, as each physician enters documents that have different appearance and terminology (3 times). The report shown to patients was found to be not so different from those they are used to seeing in their own medical records (4 participants) and clear for only 3 of them (A = 2 participants, B = 1 participant), though not in its entirety (2 participants). In 9 (A = 4 participants, B = 5 participants) proposed methods to improve communication, especially if the recipient is the patient, which puzzled 1 participant, as they do not believe the patient is the right interlocutor. Proposals for improving report communication were: providing information with less technical and clearer language (6 times), creating different standard templates, so as to improve communication with the patient (3 times), but also between doctor and doctor (2 times), showing only the necessary information in reports that have patients as interlocutors, explaining it as best as possible and reassuring the patient (3 times), focusing mainly on treatment (1 time).

Emotional aspect

The last step confirmed the misgivings about the direct communication of AI instruments with the patient because it was felt even more necessary to have the human figure acting as a mediator, a theme already analyzed in Subsection "Communication between patient, physician and AI". Ten participants, in fact, in front of the report said they felt anxiety (9 times), confusion (4 times), and worry (2 times). Also touching on the theme of the previous section, A3 says: *"I felt anxiety, in the sense that in 24 months it says elevated Alzheimer's: that's the only thing I understand. In my opinion, it is right that there is this information only for the doctor's use; then I would like instead a separate report that contains information that can help me (patient) understand better and not scare me".*

The emotional theme emerged especially in the B group, where all participants expressed themselves in emotionally negative terms, emphasizing the coldness of communication (5 times) and lack of empathy (4 times). In particular, 2 participants raised the issue related to medical ethics and transparency, arguing that the practice of wanting to inform the patient of everything may lead them to surrender to the disease, as the psychological aspect is important, especially in severe stages. In light of these considerations, they all agreed (7 participants) that direct AI communication with the patient can only take place in non-serious cases, such as routine tests.

DISCUSSION

The results that emerged from conducting the two focus groups offer insight into the opinions and perspectives of both expert and non-expert patients on the use of AI in the medical setting. Most participants expressed a favorable attitude toward the use of AI in medical practice: the value of AI in supporting the work of physicians, particularly in the diagnostic setting, was recognized in both focus groups. AI is seen by patients involved in the focus groups as a means to tackle the challenge of analyzing large amounts of data, overcoming the limitations of the human experience-based approach. These results show that, regardless of participants' level of knowledge, there is a growing acceptance of technology as a complementary tool to traditional medical intervention.

These results are in line with a previous study conducted through semi-structured interviews with 13 participants to understand patients' perceptions and acceptance of using AI in radiology report interpretation (Zhang et al., 2021): the authors observed a generally positive attitude toward the use of AI for the interpretation of radiological reports and the identification of AI as a useful tool to help patients understand better their clinical situation and further steps in their disorders management (e.g., scheduling an urgent appointment with a clinician).

In parallel with the acceptance of AI tools in the medical field, various concerns from patients emerged during the focus groups. A major concern is the possible conflict between the opinions of physicians and those of AI in the formulation of diagnosis and treatment. This concern is more prominent in the B group, highlighting the crucial role the physician plays in establishing trust in patients. Interestingly, the two groups then dwelled on different spontaneous concerns: in the A group, the concern of data processing, privacy, and informed

consent emerged; while in the B group, the issue of AI regulation emerged, with the idea of establishing standards and requirements to ensure the quality and effectiveness of AI solutions used in medicine for all, regardless of income and territoriality. This corresponds to the results of the study by Zhang et al. (2021), with responders expressing concerns about the trustworthiness and cybersecurity, and the will to know information about the system reliability. This study showed that patients also valued knowing details about how the system functions and how its results are produced. This finding aligns with ongoing discussions about the ethical and legal implications of AI-based tools. Issues such as obtaining informed consent for data use, ensuring transparency, safety, addressing algorithmic biases, and safeguarding data privacy are crucial for maintaining patient safety, privacy, and trust, as highlighted in the study by Alì et al. (2024). Additionally, the study points out that different regions adopt various approaches to AI regulation, ranging from a policy of unrestricted innovation to a precautionary principle. These regulatory frameworks need to evolve quickly to keep up with the rapid advancements in AI and to ensure both safety and innovation in the healthcare sector (Alì et al., 2024).

During the focus groups, the importance of the physician as a mediator in the relationship between the patient, the radiologist, and AI emerged prominently. Participants believe that the physician plays a key role in interpreting and communicating AI results to patients. This results in a sense of safety and trust in medical communication, which AI alone cannot provide.

Direct communication between patients and AI has generally been rejected, as patients recognize the need for a human presence to provide personalized and reassuring explanations, especially as AI lacks the emotional support that may be provided during a face-to-face consultation with a qualified medical professional (Zhang et al., 2021). In a survey conducted in the U.S., the responders supported using AI to promote public health and medical professions, they are wary about trusting AI to make key personal health decisions (Beets et al., 2023). A Pew Research Center survey (N = 10.260) conducted in 2021 asked respondents how "excited or concerned" they would be "if artificial intelligence computer programs could diagnose medical problems" (Center, 2021). 40% of respondents were either "very" or "somewhat" excited, 24% were equally concerned and excited, and 35% were either "somewhat" or "very" concerned.

While the focus groups revealed that the role of the physician is seen as necessary, patients also expressed a strong desire to understand how the AI tools being used work. This demand for explanations is seen as imperative in order to trust the results given by AI. Most patients, mainly of the B group, would prefer generic, low-tech, understandable details, but some of them want more detailed information about how AI works. As highlighted by prior research, making system functionality understandable is advantageous as it increases the transparency of systems (Vorm, 2018).

The patients involved in our focus groups stated that the AI-generated reports do not appear very different from those in their medical records, but emphasized that they should be improved so that patients can understand them better. Participants suggest using less technical language and creating standard templates to make the reports clearer and more understandable- both for patients and physicians. Personalization and focusing on relevant information, such as the care to be followed, are seen as crucial. During the review of the reports, the emotional aspect was held in high regard, especially by the B group. Many

participants reported feelings of anxiety, confusion, and worry, emphasizing the importance of empathy and sensitivity when interacting with patients, especially when dealing with sensitive medical issues.

CONCLUSIONS AND FUTURE WORK

This study explored patients' perceptions of the use of artificial intelligence (AI) in medical and diagnostic contexts, employing an innovative focus group methodology that used a narrative story and vignettes. The participants were divided into two groups based on their level of familiarity with AI. The results revealed a generally positive attitude towards adopting AI as a support tool rather than a replacement for doctors. Participants acknowledged the potential of AI to enhance the analysis of clinical data, but also expressed significant concerns, such as the need to ensure data privacy and obtain informed consent. A central theme that emerged is the necessity for clear and accessible communication regarding AI-generated results. Patients want to understand how these tools work and prefer empathetic and reassuring mediation by doctors, especially when communicating complex or sensitive diagnoses. Additionally, there is a recognized need to standardize the language used in reports to make them comprehensible to patients, avoiding overly technical jargon.

Based on these needs identified during the focus groups, several design considerations can guide future research directions. Embracing co-design methodologies involving both physicians and patients could improve the design of AI tools, especially in terms of transparency in their operation. The end users could suggest how these tools could communicate more clearly to increase trust in the result generation process. Indeed, patients expressed the need for medical records and reports to be accessible not only to specialists but also to themselves, avoiding overly technical jargon. Thus, it would be beneficial for AI-generated reports to include explanations in less technical and more reassuring language directed at patients. Moreover, AI should be seen as a supportive tool rather than a replacement for radiologists, who act as intermediaries. It is essential that radiologists understand and trust the tools generating the results, as a lack of this trust could break the chain of communication. Therefore, these tools should be designed to clearly explain the result generation methodology to radiologists, helping them assess the reliability of the results. While the role of the radiologist is seen as irreplaceable, this does not mean that patients do not want to be informed about the technology being used. Providing clear and accessible information on how AI works and how results are produced is crucial to building patient trust. Explanations should range from general to technical, depending on the patient's knowledge level and interest in the subject. Developing explanatory tools that answer patient questions about the AI tools used in their exams could be a solution. These tools should also include information on how the AI handles sensitive data, ensuring patient data security. They could be integrated at the time of report delivery or utilized during waiting periods, such as in waiting rooms.

Lastly, it is necessary to work towards developing and implementing standards and regulations for using AI in medicine, ensuring that solutions are safe, effective, and accessible to all patients, regardless of their socioeconomic or geographical conditions. Physicians should receive adequate training on using AI tools and be involved in their

development to ensure they are well-integrated into clinical practice, irrespective of the type of diagnostic center. The legal framework for AI in healthcare continues to evolve, requiring continuous adaptation. The regulation of AI, exemplified by the ongoing work of the EU AI Act, is just the first step in establishing standard rules, highlighting the need to reshape how AI developers and healthcare professionals operate in this field. Given that this is a young and rapidly expanding field, it opens many avenues for research in regulatory and legal design.

The results of this study are consistent with the quantitative findings obtained from a survey of 2119 diagnostic patients from a diagnostic center in northern Italy (Ibba et al., 2023). Validating these results with a more heterogeneous and extensive sample would further strengthen the conclusions. This study has some limitations: the overall positive sentiment towards the use of AI tools may have been influenced by the voluntary participation in these focus groups, indicating an interest in the topic rather than complete rejection. Moreover, this study is still in an exploratory stage: it would be interesting to develop prototypes of specific AI tools aimed at addressing patients' needs for clear explanations and answers to medical questions, as well as their need for continuous support, including emotional aspects, leveraging co-design approaches that involve both patients and radiologists to unite the two different perspectives.

IMPLICATIONS FOR RESEARCH AND APPLICATION

Future research should consider co-design methodologies involving both physicians and patients to improve AI tools. This approach can enhance transparency and ensure the tools communicate effectively, building trust. Patients emphasized the need for accessible medical records and reports, suggesting AI-generated documents should use simpler, more reassuring language. AI should complement, not replace, radiologists, who are key intermediaries. It is crucial for radiologists to understand and trust the AI tools they use. Providing clear, accessible information about how AI works and generates results is vital for both patients and doctors. Prototyping specific AI tools to meet these needs, including emotional support, could improve patient care. Co-designing with both patients and radiologists will help align perspectives and refine the application of AI in healthcare.

DATA AVAILABILITY AND CONFLICTS OF INTERESTS

The data that support the findings of this study are available from University Suor Orsola Benincasa, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. The data are, however, available from the authors upon reasonable request and with the permission of University Suor Orsola Benincasa.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' Note

Chiara Tancredi managed the focus group methodology, moderation, data collection, and analysis of results. Arianna Fantesini supervised focus group methodology, moderation, and data collection. Roberta Presta contributed by handling the focus group methodology, introduction, and discussion of results. Laura Mancuso contributed by analysing the results of the focus group. Simona Ibba and Michaela Cellina contributed by working on the state of the art, introduction, and discussion of results. Marco Alì, Sergio Papa and Roberto Montanari discussed the research results within a general framework and were responsible for determining the scope of the study.

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FACTORS AFFECTING THE ADAPTATION OF AUTOMATED VEHICLES

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Abstract: *Autonomous vehicle (AV) systems will be an important technology and essential for future transportation. This study applied the Unified Theory of Acceptance and Use of Technology (UTAUT) model to study the factors influencing a user's behavioral intention to use AVs. Then, a survey questionnaire was designed to collect 250 responses from AV users, and for analysis, two software programs were used: AMOS and SPSS. The result of the study shows that social influence, facilitating condition, Electronic-Word of Mouth (E-WOM), and E-Referral positively affect behavioral intentions toward the automated vehicle. Moreover, these findings contribute to UTAUT by adding new factors to the new context.*

Keywords: *UTAUT, Automated vehicle, E-WOM, E-Referral Facilitating condition, and Social influence.*

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INTRODUCTION

The most vital application in the intelligent transportation framework field is vehicle automation. This innovation incorporates numerous inventive features, such as adaptive cruise control and Global Positioning Systems (GPS) into modern automobiles, and these components have moved the driving controls to machines from human drivers (Petit & Shladover, 2014). The utilization of intelligent transportation frameworks supports drivers and limits some driving-related monotonous assignments. In particular, interstate driving has become more secure on account of the improvement of the Cruise Control (CC), Adaptive CC (ACC), and, recently, the Cooperative ACC (CACC), where both longitudinal actuators, throttle, and brake pedals, are controlled utilizing a pre-characterized hole with the first vehicle (Milanés et Al., 2013).

Autonomous vehicles (AV) use detection and correspondence advancements to explore securely and proficiently with the least human mediation. Autonomous vehicle innovation advancement is driving commercialization. Volvo, BMW, and other vehicle producers intend to satisfy self-sufficient driving capacities in numerous vehicle models by 2040 (McKinsey Center for Future Mobility 2019). Bansal and Kockelman (2017) argued that existing examinations foresee that by 2045, AVs (explicitly Level 5 computerization without human intercession) might be taken on by 24.8–87.2% of the business.

The advancement in AV adoption will bring abundant aid to both individuals and society by improving traffic safety and fuel efficiency and avoiding Corban emissions completely (Fagnant & Kockelman, 2015). Primarily, AVs can minimize up to 90% of collisions by lessening driver faults (Cohen & Hopkins, 2019). Also, AVs are fundamental for working on the climate and tackling congestion; they can save 7–15% of fuel utilization by framing detachments, decreasing vehicle proprietorship and parking spots, and upgrading road size (Yuen et al., 2020). In addition (Wang et al., 2019) argued that AVs entail fewer human sources of info, empowering clients to perform more useful exercises during their movements. Moreover, older and handicapped people can also benefit from AVs and use them for mobility (Fagnant & Kockelman, 2015).

Not only can this cutting-edge innovation massively affect the versatility and portability of transportation frameworks, but it is additionally accepted to convey the possibility of transforming people's lives. For instance, AVs can change the existence of old people and individuals with inabilities who can't drive today (Harper et al., 2016). Also, when combined with vehicle connectivity technology, AVs are expected to reduce traffic congestion significantly and, as a result, energy consumption and energy dissipation (Chandra & Camal, 2016). In any case, genuine concerns remain concerning the guidelines, credit, protection, and security of this innovation (NHTSA, 2013). Similarly, as with other emerging advances in technology, the consumer adaptation behavior of AVs is relied upon to be under a specific degree of fluctuation. All in all, individuals will have an alternate affectability to various AV manifestations. A few clients who are more worried about driving well-being might be keen on this innovation due to the exceptionally expected security benefits (Kockelman et al., 2016).

Various researches have been led to investigate the intentions of the client to utilize autonomous vehicles AVs. A new report by Yuen et al. (2020) investigated factors influencing AV adaptation based on TAM and IDT blend. Hudson, Orviska, and Hunady (2019), considered a demographic factor in AV adaptation research. A few specialists have investigated that age, sex, and the degree of instruction impact the acceptance of AVs. Hulse et al. (2018)

investigated that, men and more youthful individuals are quicker to utilize AVs in contrast with ladies and more old age individuals. Man, Xiong, Chang, and Chan (2020) additionally directed examination of AVs variation and considered components like service quality, compatibility, perceived safety risk, and perceived privacy risk. Haboucha Ishaq and Shiftan (2017) investigated that underlying AV adopters will presumably be more youthful, more educated, and invest more time driving, in light of an examination of the acknowledgment of AVs in Israel and North America.

Shabanpour et al. (2018) set up a best-worst scaling model dependent on a new expressed inclination study on the acceptance of autonomous vehicles. In their examination, people were given a solitary AV profile and requested to pick the best and most noticeably terrible features. Results from this model found that individuals were profoundly touchy to the price tag and risk in case of a mishap and the conceivable arrangement of selective paths for AVs. Shabanpour, Shamshiripour, and Mohammadian (2018) introduced an innovation diffusion model dependent on a new overview of AV reception and found that training, age, travel examples, and mentalities were exceptionally persuasive in individuals' Autonomous vehicle adoption thing choices. Talebian and Mishra (2018) applied the theory of innovation of diffusion and specialist-based demonstration to gauge the long-haul reception of AVs. Their discoveries recommend that consumer judgments regarding automation and the eagerness to pay for rising vehicle advances are dynamic and that the people with geographic nearness and comparative socio-segment profiles will in general form social ties that outcome in uniformities in autonomous vehicle acceptance patterns.

Araújo et al. (2021) led an exploration of spa tourism based on Unified Theory of Acceptance and Use of Technology (UTAUT) and further prescribed contemplating working with facilitating conditions in another scenario. Yuen et al. (2020) investigated the component behind the Chinese cab drivers while adopting electric vehicles and suggested contemplating the effect of social influence on behavioral intention. Yuen et al. (2020) investigated, factors impacting autonomous vehicle adoption based on the utilization of the innovation diffusion model and in the future, prescribed to apply another model, for example, the UTAUT. Wu et al. (2019) and Wu, Liao, Wang, and Chen (2019) directed an investigation on the job of ecological worry in the public acknowledgment of autonomous electric vehicles in China and further prescribed to contemplate different variables to understand behavioral intention thoroughly. Based on the above directions, this study will identify factors affecting the adoption of autonomous vehicles based on UTAUT. Autonomous vehicle adoption is in the development stage in Pakistan; this study is an initial endeavor to help in the identification of behavioral intentions towards autonomous vehicle adoption.

LITERATURE REVIEW

Theoretical Underpinning

The shifting examination contexts dependent on innovation, client type, area, reception time, and undertaking performed brought about many contending theories and models. For instance, the Technology Acceptance Model (TAM), Diffusion of Innovation (DoI), Theory of Planned Behaviour (TPB), and Task Technology Fit (TTF) Theory were mostly deployed to examine

the assortment of adoption and diffusion-related issues (Dwivedi et al., 2007; Dwivedi & Weerakkody, 2007; Kapoor et al., 2014; Hwang & Grant, 2011). Social Influence from the Theory of Reasoned Action (TRA), Facilitating Conditions, and Social Influence from the Theory of Planned Behavior (TPB), Performance Expectancy. Effort Expectancy from Technology Acceptance Model (TAM), Performance Expectancy, Effort Expectancy and Social Influence from Technology Acceptance Model2 (TAM2), Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions from Innovation Diffusion Theory (IDT), Performance Expectancy from Social Cognitive Theory (SCT), Performance Expectancy from Motivational Model (MM), Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions from Model of PC Utilization (MPCU) and the Performance Expectancy, Social Influence and Facilitating Conditions from Combined TAM-TPB (C-TMA-TPB) (Amrouni, Arshah, & Kadi, 2019). Because of a thorough audit of eight predominant technology reception models, (Venkatesh et al., 2003) established a unified theory of acceptance and use of technology (UTAUT) in the organizational framework emphasizing the utilitarian value (extrinsic motivation) of organizational users after the elimination of similar/redundant constructs.

E-referral and Behavioral Intention

According to the New York Times, 65 percent of new business comes from referrals; indicating that most customers have gained through referrals and not an advertisement (Referral Marketing, 2015). Nielsen (2012) reported that consumers are four times more likely to purchase a product and/or service when referred by a friend, family member, or colleague and not through a salesperson or advert. Hence, a steady stream of referrals can attract profitable customers, and improve customer loyalty (Van-den, 2010). In the context of autonomous vehicles Talebian and Mishra (2018), The individual's willingness to pay for automation is also dynamic and changes as a result of peer-to-peer communication. This means that communication with a satisfied adopter can not only convince a potential adopter that the barriers that he/she perceives are not real (or perhaps not as important as he/she thinks) but also it is worth spending more money on AVs. Similarly, in the AV context, Yuen et al. (2020) exhibited that referrals from identified sources such as friends, family, and colleagues are more influential in the adoption of autonomous vehicles. Indeed, the perceptions of people who are important to an individual have a salient influence on whether consumers engage in a particular intention or not. So, eReferral might be more effective in the context of AV since the sender or source is known and trusted by the receiver. Further, strong-tie information sources are perceived as more credible than weak-tie information sources (Rogers, 1983). However, Abubakar et al. (2016) argue that eReferral failed to influence purchase intention. The conflict in the literature provides additional space for more exploration. Thus, the following hypothesis is proposed:

H1: Electronic Referral has a positive effect on purchase intention.

E-WOM and behavioral intention

Due to recent advancements in smartphone technology and widespread internet access, consumers are now more likely to share their opinions and recommendations about new products through various electronic media platforms such as social media, blogs, and direct communication with their peers (Gupta and Harris, 2010; Huete-Alcocer, 2017; Hwang, 2008; Hwang et al., 2013). Dubey, Sharma, Mishra, Cats, and Bansal (2022) found that word-of-mouth (WOM) on social media had a significant impact on the adoption of autonomous vehicles in the digital era. The study conducted by Liu, Rouse, and Belanger (2019) emphasizes the importance of consumer approval for the implementation of autonomous vehicles (AVs). In the context of AVs, people are more vulnerable to robot faults compared to human errors. Negative word-of-mouth resulting from these faults undermines customer confidence and, consequently, the acceptance of AVs. Reza, Jalilvand, and Samiei (2012) showed in their study that, online release significantly affects other consumers' purchasing behavior. Communication can cause e-WOM particularly important for automotive manufacturers. Via the Internet cell phone that is now becoming increasingly popular, customers read online recommendations for the product in their interest directly at the place of purchase, which could have a strong impact on their purchasing decisions. In addition, Jalilvand and Samiei (2012) conducted a study in the automobile industry and the result showed that eWOM is positively related to purchase intention in the automobile industry. With the development of electronic media emerging as a strong and reliable source of information (Shukla, 2011), the influence of interpersonal interactions (eWOM) on buying decisions has significantly increased (López & Sicilia, 2014). Online reviews act as strong informants and recommenders and significantly influence the purchase intention and actual purchase (Park et al., 2007). While referring to the eWOM given on various social media channels, it is not only the quality but also the quantity of eWOM that influences the purchase decision of consumers (Lin et al., 2013)

H2. Electronic WOM has a positive effect on purchase intention.

Social Influence and Behavioral Intention

Social impact is characterized as the number of other people who accept the client ought to embrace the new framework of technology (Venkatesh et al., 2003; Hwang, 2016; Malaquias & Hwang, 2016, Malaquias et al., 2017; Hwang et al., 2016; Hwang, 2012; Hwang et al., 2016). In the realm of autonomous vehicles, social influence refers to the prestige associated with owning an AV. It evaluates a customer's conviction on the significance of others' opinions in determining whether to utilize an AV Zhou et al. (2021). According to Kettles and Van Belle (2019), the adoption of AVs may be influenced by the social context, as they are considered the latest technology that offers customers identification and social status. The endorsements of celebrities can influence users, and they are more inclined to perceive AVs as valuable if they receive positive endorsements and are enthusiastic about using them. However, Singha et al. (2023) exhibited that social influence does not significantly affect AV adoption. Chaouali et al. (2016) showed that social influence impacts the mentality of each person regarding the utilization of new creative items through innovation and technology. In a recent research

investigation, Yang et al. (2021) stated that, in the setting of e-wallets, loved ones significantly influence individual outlook to utilize things presented through innovation.

H3:Social influence will positively influence purchase intention.

Facilitating Condition and Behavioral Intention

Facilitating conditions have been characterized as how much an individual accepts that they have the vital hierarchical and specialized foundation to utilize a particular innovation or technology (Venkatesh et al., 2003). In the context of shared autonomous vehicles, Yuen, Huyen, Wang, and Qi (2020) argued that facilitating conditions affect behavioral intentions to use the shared autonomous vehicles through perceived behavioral control and providing online training, test drives, and advertising can help to improve the enabling factors and establish favorable conditions for customers to access and comprehend SAVs readily. Similarly, Singha et al. (2023) showed that facilitating conditions and intentions to adopt AV are positively related, and purchase subsidies can enhance the adoption of AV. In other contexts, facilitating conditions and AV adoption showed a significant relationship. Peñarroja et al. (2019) affirmed that in this computerized period, facilitating conditions positively affect the information-sharing behavior of utilizing technology. These findings ensured that consumers are likely to participate in virtual communities when facilitating conditions exist. Specifically, in the context of spas, many studies have demonstrated the importance of facilitating conditions for choosing a spa during a trip. However, Klaysung (2016), for instance, highlighted parking space availability and the absence of traffic jams as important spa selection criteria for tourists in Thailand.

H4: The facilitating condition has a positive effect on purchase intention

METHODOLOGY

Research Design and Method

A structured questionnaire-based survey was conducted to assess the theoretical model. The questionnaire holds two parts. The first part was used to collect respondents' demographic information, and it included five questions on gender, age, education, and brand or company vehicle they are using. Demographic variables were measured using closed-ended questions. The second part was used to survey respondents' intention on the adoption of automated vehicles. The non-probability sampling strategy was used. This sampling strategy is useful when the population is unknown or unable to be recognized in the targeted population (Smith, 2012). Purposive sampling is a non-probability sampling method in which units are selected with consideration for a specific reason. In purposive sampling, the researcher purposefully selects the respondents because they meet clear inclusion and exclusion requirements for participation in the sample (Daniel, 2011). Purposive sampling is an incredibly useful method for the early stages of a study when participants have no familiarity with the case being studied (Sibona & Walczak, 2012).

So, purposive sampling was used to collect data from the Pakistani respondents in car parks and a hard questionnaire was given to the respondent in car parks. In this study, quantitative techniques were used, as it is recommended by (Cooper & Guinan, 2006), who argues that the greatest suitable technique is the quantitative method if the end goal to investigate the association between the factor for which the researcher is applying speculations, models, and theories and keeping these in mind. For testing theory, the quantitative method is most suitable, and also for finding the relationship between variables quantitative design is best (Creswell 2013).

The scales used to quantify all factors are incorporated into this examination. The questionnaire survey comprised two principal parts. The Likert scale was expressed to examine in what way the respondents strongly agree with a specific statement (Uma & Roger, 2003). The purpose of this 5-point Likert scale is the respondents with extra choices and well choices or the variability in their attitudes and feelings, as well as to capture (Hinkin, 1995). The five-point Likert scale offers the respondents considerably more basic alternatives from where they can, without much of a stretch, go for their grouping. The planned survey questionnaire was used for this study.

The questionnaire was distributed among the targeted respondents, and then the researcher collected the questionnaire back. Burns and Bush (2004) approved this way of collecting data. More than that, the unit of analysis was individuals. The study aimed to recognize the impact of factors affecting the adaptation of automated vehicles based on UTAUT. The individual level of investigation was considered because it gives adequate cases to measure and examine each factor of the investigation.

Measurements

E-referral was measured with four items, and e-wom was measured with six items, which were adopted from the study of Jalilvand and Samiei (2012). Social Influence was measured with four items and was adopted (Venkatesh et al., 2003). Four items were adopted from the study of Venkatesh et al. (2012) for facilitating conditions, and behavioral intentions were measured with three items adopted from the study of Shukla (2011).

Table 1. Demographics

		Freq	percent	Valib perc	Cumul perc
Gender	Male	169	67.6	67.6	67.6
	Female	81	32.4	32.4	100
	Total	250	100	100	
Age	20-30	98	39.2	39.2	39.2
	31-40	106	42.4	42.4	81.6
	41-50	32	12.8	12.8	94.4
	50 above	14	5.6	5.6	100
	Total	250	100	100	
Education	Bachelor	69	27.6	27.6	27.6
	MS/MPhil	163	65.2	65.2	92.8
	Doctorate	18	7.2	7.2	100
	Total	250	100	100	
Brand	Toyota	118	47.2	47.2	47.2
	Honda	85	34.0	34.0	81.2
	Suzuki	17	6.8	6.8	88.0
	Kia	13	5.2	5.2	93.2
	Hyundai	17	6.8	6.8	100
	Total	250	100	100	

Table 1 shows that 250 respondents were approached and that all questionnaires were returned. Most respondents were male, 168 (67.6%) while 81 (32.4%) were female. 98 respondents were between the ages of 20-29, 39.2%. 106 respondents were between the ages of 31 and 40, 42.4% of the total population. 32 were between the ages of 41 and 50, and this was 12.8% of the absolute respondents. 14 respondents were over 50 and 5.6% of the absolute respondents. It additionally addresses the education of the respondents; 69, 27.6% of respondents were four-year bachelor's holders, mostly 163, 65.2% had MS/MPhil degrees, and doctorates also took part in responses, which were 18, 7.2%. In this study, information was gathered from 5 auto companies. Most of the respondents were Toyota users, 118 (47.2%) respondents; Honda users also took part which was 85 (34.0 %); Suzuki users likewise partook, which were 17 (6.8%); KIA users 13 (5.2%) and Hyundai users 17 (6.8%) of the complete population.

RESULTS

Table 2. Descriptive analysis

	N	Min	Max	Mean	S.D	Skewnees	Kurtosis
ER	250	1.11	3.89	2.68	00.73	-0.331	-0.804
EW	250	1.94	4.06	3.13	0.56	-0.389	-0.856
SI	250	0.81	4.06	2.80	0.85	-0.081	-0.818
FC	250	2.00	3.89	3.18	0.53	-0.325	-0.618
BI	250	0.78	3.89	2.77	0.61	-0.853	1.361

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

Table 2 of descriptive statistics shows the Maximum, Minimum, and Mean values, Std. Deviation, Skewness, and Kurtosis. Data normality was first tested; the results of data normality are shown in Table 2. As revealed in Table 2, the standard deviation of all the constructs is below 1, which is well within the appropriate range identified by Bryman (2012). Moreover, Table 2 also indicates that the values of skewness and kurtosis of the variables are in the appropriate range (between +2 and -2 for skewness and between +3 and -3 for kurtosis) as specified by Kline (2015), which demonstrates platykurtic, mesokurtic, and leptokurtic distributions. Consequently, there is no issue with data normality.

Table 3. Reliability of variables

Name of the factors	No. of items	Cronbach Alpha
ER	3	0.901
EW	4	0.852
SI	4	0.960
FC	3	0.786
BI	3	0.860
Total	17	0.868

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

Table 3 shows the reliability analysis of variables. E-referral was measured with 3 items, and its Cronbach Alpha is .901; e-wom was measured with four items, and its Cronbach Alpha is 0.852; social influence was measured with four items, and its Cronbach Alpha is .960; facilitating condition was measured with three items and its Cronbach Alpha is 0.880, behavioral intentions measured with three items and its Cronbach Alpha is 0.860. Finally, the total number of items is seventeen, and its Cronbach Alpha is 0.868.

Table 4. Assessment of validity

	CR	AVE	MSV	MaxR(H)	BI	SI	EW	ER	FC
BI	0.894	0.749	0.470	0.991	**0.866**				
SI	0.951	0.831	0.088	0.990	0.296	**0.911**			
EW	0.845	0.585	0.450	0.984	0.671	0.259	**0.765**		
ER	0.915	0.786	0.040	0.989	0.200	0.178	0.108	**0.887**	
FC	0.789	0.556	0.145	0.798	0.381	0.166	0.365	0.097	**0.746**

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

To choose whether the items are loaded on their specific scales or not, Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM) ought to be directed. In this manner, to look at the significant path coefficients among latent variables, Gerbing and Anderson (1988). Appropriately, the affirmation of CFA was finished. The results in Table 4 established that all values of AVE are in their required range, which ensured that there is no issue of discriminate validity. When the CR is more significant than 0.70, and AVE is greater than 0.5, it is acceptable, as suggested by Fornell and Larcker (1981). The results also show that all the values of MSV are less than AVE, which confirms that there is no issue with discriminant validity.

Table 5: Confirmatory Factor Analysis

Items	Standardized loadings
SI1	0.86
SI2	0.94
SI3	0.99
SI4	0.85
EW1	0.69
EW2	0.75
EW3	0.61
EW5	0.97
ER1	0.66
ER2	0.97
ER3	0.99
BI1	0.99
BI2	0.97
BI3	0.99
FC1	0.67
FC2	0.78
FC3	0.78

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

The above is the table of loadings in the confirmatory factor analysis. The CFA test was applied to check the model fitness of the present research study. The results were according to our expectations and showed that all the values were within the acceptable range. As Comrey and Lee (1992) suggested, loadings from 0.32 *(Poor)*, 0.45 (*Fair)*, 0.55 (*Good*), 0.63 (*Very Good*), or 0.71 (*Excellent*). According to Lowry and Gaskin (2014), a suitable fit to the data can be confirmed if all factor loadings are above 0.60 and the $\chi 2/df$ value is between 1 and 5.

Table 6. CFA

	Initial Fit Indices		Modifications	Final Fit Indices	
Nested Model	X^2	639.08	**Covariance**	X^2	152.7
			Covariance's		
	Df	142	e1 ↔ e4	*Df*	107
	X^2/df	4.501	e5 ↔ e6	X^2/df	1.42
	GFI	0.795	Deleted	GFI	0.936
	AGFI	0.726	FC4	AGFI	0.909
	NFI	0.861	EW4	NFI	0.963
	CFI	0.887	EW6	CFI	0.989
	RMSEA	0.110	ER4	RMSEA	0.041

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

The CFA was applied to check the model's fitness. Four items were removed due to low loading. The results indicate that the value of $X^2/df = 1.42$, within the acceptable range, as high as 5.0 (Wheaton et al., 1977). The value of GFI is .936, and AGFI is .909. Both are in the acceptable range, as suggested by Doll et: the value is acceptable if it is above 0.8. According to Ahire et al. (1996), the NFI has been calculated to full fill the first method of finding a model fit. The value of NFI is 0.963 > 0.90, CFI is 0.989 > 0.90, and RMSEA = 0.041 < 1, which is also in the acceptable range (MacCallum et al., 1996).

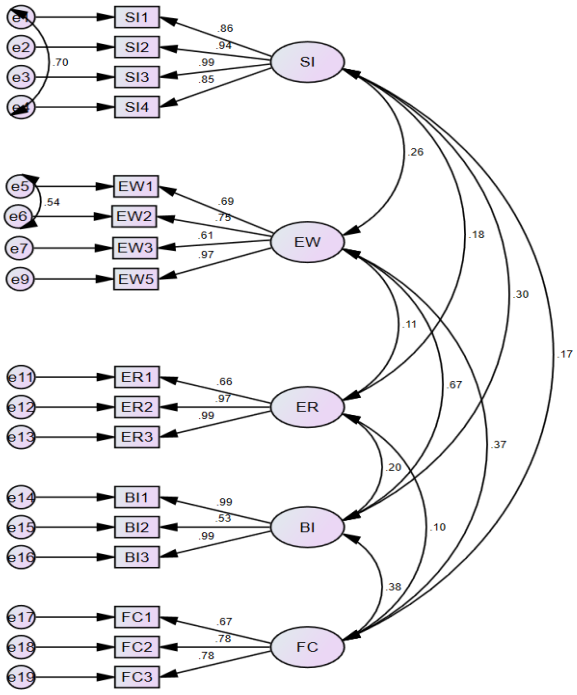

Figure 1. CFA model

Table 7. SEM Hypothesis Testing

Hypotheses	hypotheses path	Path Coefficient	SE	CR	Sig	Status
H1	ER-->BI	0.132	0.065	2.04	0.041	Accepted
H2	EW-->BI	0.706	0.074	9.52	0.000	Accepted
H3	SI-->BI	0.105	0.043	2.42	0.015	Accepted
H4	FC-->BI	0.337	0.097	3.46	0.000	Accepted

Note: SI: Social Influence, EW: E-Wom, ER: E-Referral, BI: Behavioural Intentions, FC: Facilitating Conditions

Table 7 of the direct path model shows H1: ER positively impacts BI, β = 0.132, CR = 2.04 with P value .041 < 0.05. H2: EW positively impacts BI, β = 0.706, CR = 9.52 with p value 0.000 < 0.05. H3: SI has a positive impact on BI, β = 0.105, CR = 2.42 with p value 0.015 < 0.05. H4; FC has a positive impact on BI, β = 0.337, CR= 3.46 with p value 0.000 < 0.05.

The results are confirmed by X^2 = 216.3, df = 130, and X^2/df = 3.56. GFI = 0.843, AGFI = 0.792 NFI= 0.901, TLI = 0.913 CFI = 0.926, IFI = 0.927 and RMSEA = 0.101. As indicated by Hair et al. (2016), the structural equation model fit measures can be up to the required standards when the value of χ2/df is between 1-5, NFI, AGFI, TLI GFI, IFI, and CFI values are less than 1 and RMSEA = 0.101<1 which is also in the acceptable rand (MacCallum et al., 1996).

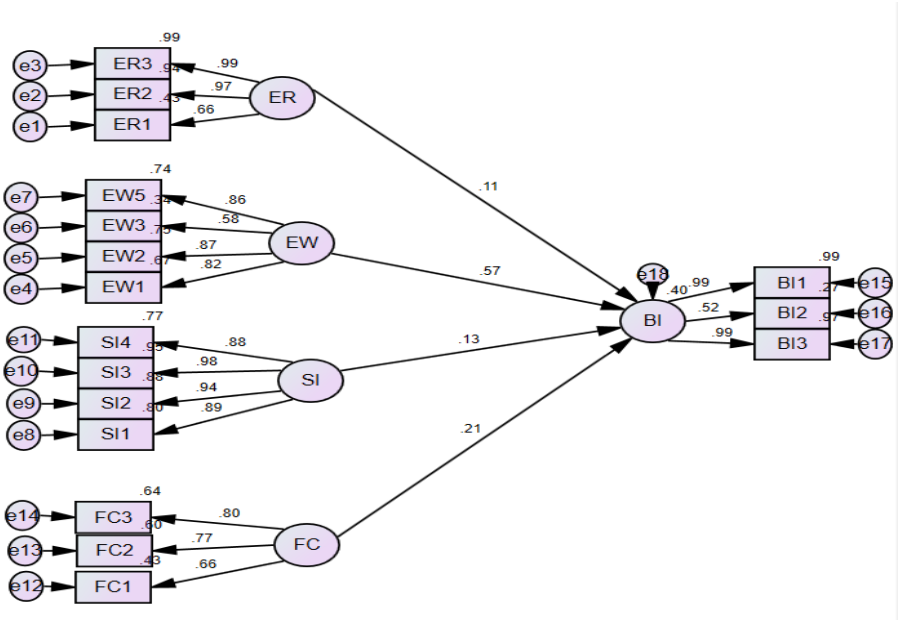

Figure 2. Path Model

DISCUSSION

In this research study, factors affecting the adoption of the automated vehicle have been examined, Factors include e-referral, e-wom, social influence, facilitating condition, and its effect on behavioral intentions. These were four hypotheses in this study. H1. The results showed a positive relationship between e-referrals and behavioral intention toward automated vehicles ($\beta = 0.132$, $p < 0.041$, CR = 2.04). The result has been confirmed by the previous findings of Van-den (2010) and Nielsen (2012). The current study provided strong empirical evidence for the relationship between e-referral and behavioral intention toward automated vehicles. In other words, when an individual gets a recommendation online from a trusted and identified source, they are more likely to adopt the AV. However, some of the previous studies failed to show a positive relationship between e-referral and behavioral intentions due to the small sample size, and there were Greeks in the respondents, who are proud of their Western culture and are more individualistic (Abubakar et al., 2016; Fong & Chuang, 2004, p. 281). Similarly, the result of H2 also showed a positive relationship between e-wom and behavioral intention toward automated vehicles ($\beta = 0.706$, $p< 0.000$, CR = 9.52). The findings align with previous studies (Subramani & Rajagopalan, 2003; Chatterjee, 2001). The results indicated that ewom is an important factor in influencing consumers to accept AV. Online reviews, blogs, and communities play an important role in the adoption of AV. The association between social influence and behavioral intention is positive ($\beta = 0.105$, $p < 0.015$, CR = 2.42). Earlier research by Kettles and Van Belle (2019) in this field supported the results of H3. However, Ahmad, Chaveesuk, and Chaiyasoonthorn (2024) showed an insignificant relationship in the electric vehicle adoption domain. The finding exhibited that suggestions from social groups and celebrities play an important role in adopting AV, and consumers perceived it as a status symbol. H4 showed a positive relationship between facilitating conditions and behavioral intentions ($\beta = 0.337$, $p < 0.000$, CR = 3.46). Previous Studies by Zhou et al. (2021) and Peñarroja et al. (2019) supported the results of the current study. The results showed that facilities such as maintenance infrastructure, parking slots, online training, and test drives could lead consumers to adopt AV.

CONCLUSION

Automated vehicles and their features are considered innovative and convenient which offers multiple features to the consumers. These features ensure consumers' safety and security and also feel easy to use while driving. This study is an initial endeavor to identify factors affecting the behavioral intentions toward automated vehicle adaptation based on UTAUT in Pakistan. The results indicated that e-referral, e-wom, social influence, and facilitating conditions have a positive effect on behavioral intentions towards automated vehicles. The results of the study showed that focusing on these factors can lead to positive behavioral intentions. This study was conducted in Pakistan, which is a developing country, where people have low buying power, and automated vehicles are costly for many people. Thus, in the future, researchers should consider other factors such as price value and income. Secondly, this study has not considered the actual use of automated vehicles and also identified awareness as a moderator in the relationship. Lastly, the researcher should conduct this study in other settings.

THEORETICAL AND PRACTICAL IMPLICATION

This study was conducted in the context of the automobile industry and focused on autonomous vehicle adoption. Most consumers are unaware of the benefits of autonomous vehicles, and some do not know how to use them. This study studied four factors: e-referral, e-wom, social influence, and facilitating condition. This study has contributed two more factors to the literature on UTAUT: e-wom and e-referral. Both factors play an essential role in the adoption of automated vehicles, but e-wom was shown to be more effective in this study. The study also tested social influence and facilitating conditions in the AV context in Pakistan. This study contributed to the existing body of knowledge on consumer behavior while adopting new technologies because it has explored the antecedents of behavioral intention towards automated vehicles based on UTAUT. This research study also has implications for managers. The results confirmed the factors which influence behavioral intentions. The manager of the auto industry should consider these factors to build positive consumer behavior and achieve its goal. Managers should use online communication to spread awareness about AV, motivate consumers to do referrals, and share with them about the test dives of AV and the facilities that AV companies are offering in the market. Managers should also engage with consumers through online blogs, pages, and groups and keep sharing content related to AV in order to convince consumers. The manager should hire celebrities and influencers to promote AV adoption in Pakistan.

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Appendix

Social Influence
People who influence my behavior think that I should use an automated vehicle
People who are important to me think I should use an automated vehicle.
In general, society has supported the use of automated vehicles.
Having an automated vehicle is a status symbol in my circle.

Facilitating Condition
The resources necessary to use automated vehicles exist.
I have the knowledge necessary to use automated cars.
Automated vehicle is compatible with other technologies I use.
I can get help from others when I have difficulties using an automated vehicle.

Ewom
I often read other users' online reviews to know what automated vehicle brands make good impressions on others.
To make sure I buy the right brand, I often read other users' online reviews about automated vehicles.
I often consult other users' online reviews to help them choose the right automated vehicle.
I frequently gather information from online users' product reviews before I buy a certain automated vehicle.
If I don't read consumers' online product reviews when I buy an automated vehicle, I worry about my decision.
Consumers' online reviews make me confident in purchasing when I buy an automated vehicle.

E-referral
I often buy automated vehicles referred by my friends, colleagues, and family.
I often buy automated vehicles referred by trusted firms and social network sites.
When I buy an automated vehicle not referred, I worry about my decision.
Online referrals increase my confidence in purchasing an automated vehicle.

Behavior Intentions
I intend to use automated vehicles in the future.
I will always try to use automated vehicles in my daily life.
I predict I will use automated vehicles in the future

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DISTRACTED PARENTING: HOW DO PARENTS' EMOTIONAL REGULATION AND PROBLEMATIC SMARTPHONE USE CONTRIBUTE TO THE INTERRUPTIONS OF PARENT-CHILD INTERACTIONS?

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Abstract: *This study aimed to examine the associations between parents' difficulties in emotion regulation, risk for smartphone addiction, and interruptions of parent-child interactions. The sample comprised 281 parents (80.9% mothers) who participated in the project "Digital technology in the family: patterns of behavior and effects on child development". Parents completed the Difficulties in Emotion Regulation Scale (DERS-16; Bjureberg et al., 2016) and the Smartphone Addiction Scale (SAS-SV; Kwon et. al., 2013). Additionally, parents rated how often they use and check their smartphones during parent-child interactions on a newly developed scale as an indicator of interruptions. The results show that parents with greater emotion regulation difficulty have a greater risk for smartphone addiction and report a higher frequency of using and checking their smartphones during parent-child face-to-face interactions. Thus, there is a significant indirect effect of emotion regulation difficulties, through risk for smartphone addiction, on interruptions of interactions between parents and children. The findings are further examined within the context of parents' characteristics that may be risk factors for the prevalence of interruptions of parent-child interactions.*

Keywords: *parents, interruptions of parent-child interactions, technoference, emotional regulation, smartphone use.*

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INTRODUCTION

There is no systematic research in Croatia on parents' smartphone use and its correlations, especially in the family environment. Parents' mobile device use is primarily explored in terms of how much they use mobile devices in general, the main reasons for their use while with children, how the use contributes to disruptions in their close dyadic interactions, and how the use can affect their parenting behaviour and child development. Parents use mobile devices while with children, especially smartphones, for different reasons, e.g., seeking relief from the stress or boredom of parenting, managing emotions as they deal with children and parenting, and facilitating various parenting tasks (McDaniel, 2020; Radesky et al., 2016). Mobile device use during parent-child interactions is linked to more distractions and interruptions of face-to-face interactions, known as technology interference, or technoference, in literature (McDaniel, 2019). The term specifies interruptions in interpersonal interactions caused by technology, namely smartphone use (e.g., McDaniel & Coyne, 2016; McDaniel & Radesky, 2018a). Numerous studies have confirmed the existence of technoference in caregiver-child interactions (e.g., Elias et al., 2021; Newsham et al., 2018; Radesky et al., 2014). These interruptions of direct interactions with children are related to less responsiveness towards children, less positive communication, and negative parenting behaviours (e.g., Elias et al., 2021; Hiniker et al., 2015; McDaniel & Radesky, 2018a). Evidence shows that greater parenting stress predicts greater technoference (McDaniel & Radesky, 2018a). In this study, the expression "technoference" refers to interruptions in parent-child face-to-face interaction due to parents' use of smartphones. Alternetively, the term "phubbing" is frequently used in the literature to refer to the interruptions in social interactions (Chotpitayasunondh, & Douglas, 2016). However, phubbing differs from technoference, as phubbing implies intentional use, while technoference encompasses the inadvertent influence of technology on communication, such as interruptions from notifications or unconscious device checking during conversations.

Current literature points to the theory that when parents frequently use smartphones during their time with children, they feel distracted and are less responsive as parents, which consequently has negative effects on child well-being and development (e.g., Dolev-Cohen & Ricon, 2022; McDaniel & Radesky, 2018a, 2018b; McDaniel, 2019; Merkaš et al., 2021; Stockadale et al., 2018). For example, more externalizing and internalizing problems, and lower social skills in children (e.g., Dolev-Cohen & Ricon, 2022; Knitter & Zemp, 2020; McDaniel & Radesky, 2018a, 2018b; Merkaš et al., 2021; Yang et al., 2023). A possible conceptual basis that might shed light on these patterns is the displacement hypothesis (Valkenburg & Peter, 2007). This hypothesis states that people while using technology, may displace other activities that are beneficial to their mental health, like face-to-face interactions with others (McDaniel, 2015). In other words, when parents shift signs of (non)verbal communication from face-to-face to technology devices, it can become a potential threat for some maladaptive outcomes in children (e.g., Hiniker et al. 2015, Radesky et al., 2014). In this way, parents miss out on opportunities to fulfill their child's needs, and children miss out on getting parental support when learning new behavioural patterns, like emotional regulation (Stockdale et al., 2018). Considering this, it seems important to examine whether any individual factors make parents prone to frequent, namely problematic smartphone use and a consequently higher incidence of technoference in parent-child interactions. Identifying

individual vulnerability factors for parents' frequent and problematic smartphone usage and experience of technoference cloud gives us important insights into where to do prevention and intervention.

A little research examines parents' characteristics that may be related to technoference or could make them more prone to experiencing technoference. The small range of existing research still gives an important insight into parents' characteristics and smartphone use patterns that could relate to technoference. Research has shown that one of the main predictors of technoference in parent-child interactions is parents' general smartphone use (e.g., Dolev-Cohen & Ricon, 2022; Knitter & Zemp, 2020; McDaniel & Radesky, 2018a, 2018b; Merkaš et al., 2021; Yang et al., 2023). The more parents use their smartphones, regardless of their activities, the more disruptions in their interactions with children they will experience and the higher their risk of problematic smartphone use. Some parents may develop problematic smartphone use or smartphone-related addictive behavior, which can manifest as an excessive preoccupation with smartphone use, experiencing uncomfortable emotions when unable to engage with the smartphone, and facing personal and interpersonal challenges stemming from smartphone use (Csibi et al., 2021). This kind of use is complexly related to various mental health issues, such as negative affect and autonomy (Horwood & Anglim, 2019). This may suggest that individuals who struggle with excessive (i.e., problematic) smartphone use may perceive themselves as helpless and experience a lack of control over their own lives (McDaniel et al., 2023), but also lack of control over their social interaction and, more basically, their behaviour and emotions. This also may imply that these individuals have difficulties regulating their behaviour and emotions.

Difficulties in emotion regulation or emotional regulation difficulties are indicated by, for example, the inability to carry out purposeful actions during distress, struggles with controlling impulsive behaviours in moments of distress, restricted use of perceived effective emotion regulation strategies, and lack of emotional clarity (Bjureberg et al., 2016). The significant link between emotion regulation challenges and problematic patterns of smartphone use is mainly obtained from samples of adolescents and undergraduate students (e.g., Fischer-Grote et al., 2019; Horwood & Anglim, 2021; Wacks & Weinstein, 2021), and there are not many studies done with adults, especially parents. A rare study done by Giordano et al. (2021) showed that emotional dysregulation in parents is associated with their excessive smartphone use, measured using the Smartphone Addiction Inventory. Currently, the evidence points to a low to moderate positive correlation between emotional dysregulation and problematic smartphone use; the older the person, the weaker the link between these constructs is (Shahidin et al., 2022). The positive link is not surprising given that difficulties with emotion regulation underline various addictive behaviours and psychopathologies (Shahidin et al., 2022). So, parents who face difficulties while regulating their emotions may be more likely to become engaged in problematic or addictive smartphone use as an attempt to manage their feelings and current states, consequently becoming more distracted in parent-child interactions. On the other hand, certain studies indicate that elevated emotional stability, assessed as a personality trait in parents, has the potential to mitigate the adverse impact of technoference on children (e.g., Merkaš et al., 2021; Morris et al., 2022), but only at a low level of technoference (Merkaš et al, 2021). It seems that parental emotional regulation could be an important individual-level factor that is

linked to problematic smartphone use and technoference in parent-child interactions, but the literature lacks empirical evidence for the statement.

The Current Study

Up-to-date research has focused on how technoference in parent-child interaction negatively affects child development. From the perspective of preventing the negative effect, the question arises about what predicts technoference in parent-child interactions. We raise the question of individual vulnerability factors of parents that make them more sensitive to experience technoference when with children. Thus, in this paper, we are focused on individual characteristics of parents that could be related to technoference since this topic has not been explored enough, especially from the perspective of parents. More precisely, the focus is on difficulties in emotional regulation and the risk of smartphone addictions that are directly or indirectly related to technoference. Moreover, this study aims to investigate risk factors observed within the dyadic, parent-child relationship. Thus, this study aims to examine the association among parents' difficulties in emotion regulation, the risk for smartphone addiction, and technoference in parent-child interactions. Research in Croatia has mainly focused on children's use of smartphones (Jokić et al., 2022; Merkaš et al., 2021) and there are gaps in the literature considering parent's smartphone use in the family context. Rare studies in Croatia with parents of children aged 3 to 14 years show that technology interference due to parents' smartphone use may negatively affect a child's social competence but parents' emotional stability may buffer this effect (Merkaš et al., 2021). Furthermore, data from the longitudinal study conducted within the "Digital technology in the family: patterns of behavior and effects on child development" project show that higher technoference is associated with parents' estimates of higher incidences of parent-child conflict about the child's smartphone use time. Results also show that children's estimates of higher incidences of parent-child conflict over the time children use smartphones are related to children's lower life satisfaction and higher negative affect (Kotrla Topić et al., 2023). The findings point to the importance of parents' smartphone use during parent-child interactions and parent-child conflict over smartphone use for children's well-being (Kotrla Topić et al., 2023). There are no studies about the predictors of parental smartphone use during interactions with their children. It is important to examine these predictors, as they could be risk factors. Preventive and interventive actions on these risk factors could reduce the negative effects of interruptions in parent-child interactions.

Based on the literature, we postulated two paths from emotion regulation difficulties to higher technoference in parent-child interactions, one direct and one indirect. We hypothesize that (a) higher emotion regulation difficulties will be directly associated with a higher incidence of technoference in parent-child interactions (direct path); (b) higher emotion regulation difficulties will be associated with a higher risk of smartphone addiction, which will be related to an elevated incidence of technoference in parent-child interactions (indirect path).

If the evidence supports the hypotheses, parents' difficulties in emotion regulation and problematic smartphone use, could be labeled as individual parents' vulnerability factors for experiencing higher technoference in parent-child interactions. This could shed light on a

space where prevention of technoference in parent-child interactions could firstly take place by strengthening parents as individuals.

METHODS

Sample

The sample comprised 270 parents (80.9% were mothers; average age 43 years (M = 43.41, SD = 4.8) of children (59.8% were girls) aged 10 to 15 years (M = 12.23, SD = 1.207) who participated in a longitudinal study (the first wave) within the project "Digital technology in the family: patterns of behavior and effects on child development". In terms of education, most fathers (58.7%) and mothers (49.1%) had completed high school, while a significant portion of fathers (37.3%) and mothers (48.4%) held higher degrees. A small percentage of fathers (4%) and mothers (2.5%) had only completed elementary school. Regarding employment, most of both fathers (80.1%) and mothers (73.1%) were employed full-time, while a small percentage of fathers (5.1%) and mothers (14.2%) were unemployed. Some fathers (11%) and mothers (11.6%) worked part-time, and a small percentage of fathers (3.7%) and mothers (1.1%) were retired. Most are two-parent families (85.6%) in the sample. Most of the parents have two children (50.2%), 13.4% have one child, and 36.5% have more than two children. The monthly income for most families (66.9%) was below 730.00 EUR per family member, while one-third of families (33.1%) had a monthly income above this amount. The range of monthly household income per person ranged from below 199.08 EUR (1.2%) to above 1260.87 EUR (10.8%). To summarise, most families included in the study belonged to families from the middle to upper socioeconomic classes.

Measures

Emotion regulation difficulties in parents were examined with the Difficulties in Emotion Regulation Scale (DERS-16; Bjureberg et al., 2016). The scale includes 16 items (e.g., "When I am upset, my emotions overwhelm me"). DERS-16 assesses dimensions of emotion regulation difficulties: nonacceptance of negative emotions, inability to engage in goal-directed behaviours when distressed, difficulties controlling impulsive behaviours when distressed, limited access to emotion regulation strategies perceived as effective, and lack of emotional clarity. Parents rated the extent to which each item applies to them on a 5-point scale from 1 (almost never) to 5 (almost always). Factor analysis revealed a one-factor solution, with the percentage of explained variance by one factor being 39.56%. The reliability of this scale, as examined by Cronbach's alpha coefficient, is $\alpha = 0.91$. The score on DERS-16 is calculated as the mean of all the items, with a higher score indicating greater difficulties in emotion regulation.

The risk for smartphone addiction was measured with the Smartphone Addiction Scale (SAS-SV; Kwon et al., 2013), which consists of 10 items that measure the extent to which a smartphone interferes with daily activities (e.g., "I miss planned obligations because of smartphone use"). Participants respond to each item on a scale ranging from 1 (strongly disagree) to 6 (strongly agree). Exploratory factor analysis showed a one-factor solution consistent with expectations (Kwon et al., 2013). The percentage of common variance by one

factor was 31.35%. The reliability of the questionnaire was assessed using Cronbach's alpha coefficient, which was 0.79. The score is determined by averaging all items, and a higher score suggests an increased risk of smartphone addiction.

Technoference in parent-child interactions, meaning interruptions of parent-child face-to-face interaction due to parents' use of mobile phones, was measured with a newly developed scale constructed for the purposes of this project. Parents rated how often they check their mobile phone during a family meal, use their mobile phone while they are talking to their child, check their mobile phone if it rings even if they are talking to their child, and use their mobile phone while with a child (e.g., during play, joint-free time) on a 5-point scale from 1 (never) to 5 (always). All four items were loaded onto one factor according to the factor analysis, which explained 48.72% of the variance, and the Cronbach alpha coefficient was 0.767. The overall score was determined by averaging the scores of all items, where a higher score indicated a greater level of technoference in the parent-child relationship.

Procedure

The research was carried out within the framework of a project "Digital technology in the family: patterns of behavior and effects on child development" that has ethical permission from the Ethical Committee of the Catholic University of Croatia and the permission of the Ministry of Science and Education of Croatia for the conduction of the study in schools. Elementary schools from the city of Zagreb and Zagreb County, Croatia, were contacted by the research team. Information and materials were sent to the schools via e-mail, including an invitation letter for the principal, a project approval form, informed consent forms for parents and children, copies of the questionnaire, and a protocol for school associates. Data was collected between December 2021 and March 2022. A total of 22 schools were contacted, and six schools agreed to participate in the study. The school associates, specifically school psychologists, provided the number of children in the 5^{th} to 8^{th} grades, and each school received sets of research materials based on that number. A total of 1096 sets were provided, each containing informed consent forms for parents and children, a questionnaire for parents, and the first part of the questionnaire for children in sealed envelopes. The children took the envelopes home, and if both they and their parents agreed to participate, they returned the envelopes with the completed materials to the school. The participation rate was 25.7% of all the contacted children and parents. Due to the length of the questionnaire, it was divided into two parts for the children, so children who participated in the first part of the study later completed the second part during regular school classes. The questionnaires were administered by school psychologists, and the group administration took approximately 20 minutes. Every participating child and parent received a coupon for the local zoo as a token of appreciation.

Data Analysis

Data for this research were processed using the SPSS program and Mplus program version 8 (Muthén & Muthén, 2020). Prior to statistical data processing, checks to identify any extreme values and outliers in the data that could potentially skew the results were calculated. Additionally, internal consistency coefficients and distributions of scores on the utilized

scales were examined. Internal consistency coefficients are satisfactory and exceed the reference values in the literature.

Concerning the normality of the distribution of results, the skewness and kurtosis values of the variables fell within the range of +1.5 and -1.5 (Kline, 2011). The correlation between variables in the study was examined using Pearson's correlation coefficient. To address the research question related to checking the mediating effect, Mplus program version 8 (Muthén & Muthén, 2020) was employed. To assess the fit of the data with the model, parameters such as the $\chi 2$ test, the values of the incremental indices CFI (Comparative Fit Index) and TLI (Tucker-Lewis Index), RMSEA (Root Mean Square Error Approximation), SRMR (Standardized Root Mean Square) were calculated (Hu & Bentler, 1999).

RESULTS

Descriptives and correlations between study variables

On average, parents report low levels of difficulty with emotion regulation, and low levels of risk for smartphone addiction. Parents reported, on average, that they rarely use and check mobile phones while interacting with children. Within the study, the frequency of parents' responses to technoference-related questions was analyzed. The results, based on the combined responses of "usually" and "always", revealed that approximately 3.2% of parents admitted to checking their phones during family meals, while 4% of parents acknowledged using phones during conversations with their child usually and always. Around 17.5% of parents stated that they check their phone when it rings even if they are talking to their child "at the moment", and 6.1% use a smartphone while they are with their child usually and always.

The correlations in Table 1 show that difficulties in regulating emotions among parents are directly correlated with an increased likelihood of smartphone addiction and the occurrence of technoference in parent-child interactions. There is also a positive correlation between the likelihood of smartphone addiction and the occurrence of technoference in parent-child interactions.

Table 1. Means (M), standard deviations (SD), and correlations between study variables

	M	***Sd***	***min***	***max***	***med***	**1**	**2**	**3**
1. DERS	1.73	0.53	1	5	1.69	-	.404**	.255**
2. SAS	1.99	0.65	1	6	1.9		-	.373**
3. TECH	2.03	0.71	1	5	2			-

Note: *p < .05; **p< .001; DERS – Difficulties in Emotion Regulation Scale; SAS – Smartphone Addiction Scale; TECH - Technoference in parent-child interactions due to parents' use of smartphone

Testing the effect of difficulties in emotional regulation and risk for smartphone addiction on technoference in parent-child interactions

Based on the literature and the hypotheses, a theoretical model was developed and tested (Figure 1). According to the model, (a) higher emotion regulation difficulties will be directly related to a higher incidence of technoference in parent-child interactions (direct path); (b) higher emotion regulation difficulties will be related to a higher risk of smartphone addiction, which will be related to a higher incidence of technoference in parent-child interactions (indirect path).

The path analysis was used with variables being represented as observed variables, meaning that the mean scores on each variable were taken into analysis. To assess the impacts, an ML estimator was applied, and bootstrap confidence intervals (CI) for the effects were derived from 1000 samples. The model was tested using the Mplus program version 8 (Muthén & Muthén, 2020).

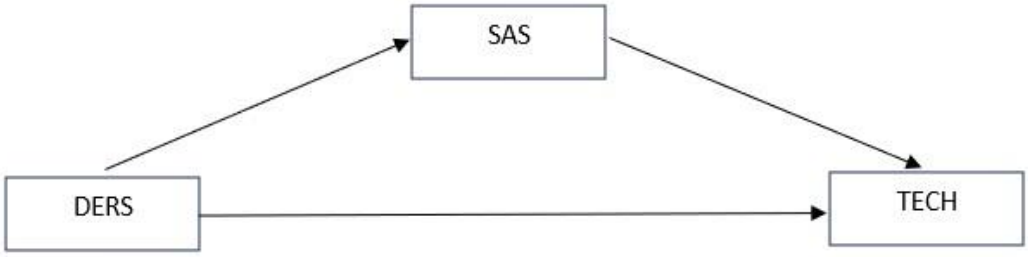

Figure 1. A theoretical model of the relationship between difficulties in emotion regulation (DERS), risk for smartphone addiction (SAS), and technoference in parent-child interactions due to parents' use of smartphones (TECH)

We first tested for the measurement model. The conducted analysis showed adequate goodness of fit statistics of the measurement model. Specifically, the following values were obtained: $X^2 = 94.842$, df = 3, $p < .001$; CFI = 0.979; TLI = 0.938; RMSEA = 0.084 <0.000 - 0.204>; SRMR = 0.032. All correlations between the variables in the model were significant.

In the second step, the model (Figure 1) with the hypothesized direct and indirect effect of emotion regulation difficulties to technoference was tested. Fit indexes for this model were: $X^2 = 94.842$, df = 3, $p < .001$; CFI = 1.00; TLI = 1.00; RMSEA = 0.000 <0.000 - 0.000>; SRMR = 0.000. Given that the proposed effect from emotion regulation difficulties to technoference in the parent-child relationship is not significant ($\beta = 0.106$, $p > 0.05$), we omitted it from the model and tested the full mediation model that examines the assumption that emotion regulation difficulties only indirectly (through addictive smartphone use) contribute to technoference in the parent-child relationship. The results demonstrated an adequate fit for the full mediation hypothesized model, so this model was accepted. Indices of fit for the full mediation model were: $X^2 = 94.842$, df = 3, $p < .001$; CFI = 0.979; TLI = 0.938; RMSEA = 0.084 <0.000 - 0.204>; SRMR = 0.032. Furthermore, the indirect effects were assessed using the bootstrapping method (1.000 bootstrap resamples). The statistical significance of the examined indirect effect was evaluated through 95% confidence intervals. The indirect effect is considered significant if the confidence interval of the unstandardized mean beta weight does not include the value of zero (Preacher & Hayes, 2008). Results show

a significant indirect effect of risk for smartphone addition in the relationship between emotion regulation difficulties and technoference in the parent-child relationship (0.169, $p < .001$; CI: <0.068 - 0.258>).

Table 2. Model results for testing the indirect effect of parents' emotional regulation difficulties on technoference in parent-child interactions

	β	S. E.
DERS → SAS	0.421**	0.052
SAS → TECH	0.401**	0.058
DERS → TECH	0.106	0.087
DERS → SAS → TECH	0.169**	0.034

Note: **p < .001; DERS – Difficulties in Emotion Regulation Scale; SAS – Smartphone Addiction Scale; TECH - Technoference in parent-child interactions due to parents' use of smartphone

DISCUSSION

The study aimed to examine the association among parents' challenges in emotion regulation, the risk for smartphone addiction, and technoference in parent-child interactions. The current study shows that in the sample of parents in Croatia, parents' emotion regulation difficulties do not directly contribute to technoference in parent-child interactions but indirectly. Parents' greater difficulties in managing emotions are related to a higher risk of smartphone addiction, which is then associated with a higher incidence of technoference in parent-child interactions.

Individuals who face challenges in managing their emotions may escape from some unpleasant emotions in the immersive world their smartphone offers. Emotion dysregulation can occur during efforts to alleviate uncomfortable emotions or enhance comfortable emotions as indicated by Gross (2015). The results of this study are in line with the previous studies indicating that higher emotion regulation challenges are associated with a higher risk for smartphone addiction in parents (e.g., Giordano et al., 2021; Squires et al., 2021). In this research, the DERS-16 (Bjureberg et al., 2016) was used, a measure explicitly designed to evaluate difficulties in regulating unpleasant emotions. So, the findings of this research indicate an association between dysfunctional efforts to alleviate uncomfortable emotions and increased smartphone use. This result aligns with the impulse pathway outlined in a model of problematic smartphone use proposed by Billieux (2012). Following Bilieux's model, unpleasant emotions may contribute to the internalization of ineffective emotion regulation strategies, ultimately resulting in excessive smartphone use as a means to distract attention from unpleasant emotional states. Several other theories and models (e.g., Brand et al., 2014; Kardefelt-Winther, 2014) propose that individuals who face difficulties in emotion regulation often resort to using smartphones as a means of distraction from unpleasant feelings.

Furthermore, the current study shows that parents who are more prone to develop smartphone addiction patterns experience more technoference in in-person interactions with their children. The reported outcome aligns with prior research findings, indicating that parents demonstrating problematic smartphone use or being at a heightened risk of smartphone addiction tend to avoid detachment from their smartphones (Cho & Lee, 2017). Smartphone addiction often involves compulsive use and constant attention to the device

(De-Sola Gutiérrez et al., 2016). Thus, parents might be easily distracted by their smartphones and are prone to engage in activities on their smartphones for an extended period of time even during in-person interactions with their children (e.g., McDaniel & Radesky,2018; Newsham et al., 2020; Sundquist et al., 2020).

This study further shows that the risk of smartphone addiction is the significant mediator in the relationship between emotion regulation difficulties and technoference in parent-child interactions. Parents with greater challenges in emotional regulation may be more prone to develop some maladaptive and excessive smartphone use to handle their unpleasant feelings and psychological states. As a result, those parents may become more interrupted during face-to-face interactions with their children, namely because of using and checking their phones. The intrusion of technology devices (e.g., smartphones) can disrupt and hinder meaningful parent-child interactions, as the parents' attention and focus are diverted towards their smartphones rather than being fully engaged in the interaction with their juveniles (e.g., Abels et al., 2018; Kushlev & Dunn, 2019 Valkenburg & Peter, 2007). The results obtained suggest a significant association between challenges in parents' emotion regulation, smartphone use, and the potential adverse effects on the quality of interactions between caregivers and children. In the context of the Differential Susceptibility to Media Effects Model proposed by Valkenburg and Peter (2013) difficulties in emotion regulation in parents can be considered as personal factor that influence media selection and responsiveness to digital technology use. Namely, Valkenburg and Peter (2013) suggest that there are some personality traits or dimensions (such as gender, temperament, personality traits, cognitions, attitudes, beliefs, motivations, and moods) that are crucial in understanding the effects of digital technology use. Emotional dysregulation related to negative affect can be seen as a personal factor that shapes parents' problematic and addictive use of phones during face-to-face parent-child interactions. So, parents with higher emotional dysregulation may tend to use their phones for regulation of negative affect. Consequently, this pattern of behavior may translate to parent-child interactions and interrupt face-to-face interactions.

On the other hand, this study suggests that challenges in emotion regulation that parents face do not directly contribute to technoference in parent-child interactions. The results obtained align with findings from earlier studies conducted in Croatia (Merkaš et al., 2021) according to which at a low level of technoference in parent-child relationships, as observed in the current study, emotional stability as a personality trait can mitigate the negative impact of technoference. Additionally, the obtained result may also suggest that parents who regulate their unpleasant emotions using some adaptive strategies and through means other than using smartphones (e.g., cognitive reappraisal) during active face-to-face interaction moments (e.g., discipline, bedtime, conversation with child) may not frequently use smartphones while with child.

This study concentrated on examining the association of certain caregivers' attributes associated with smartphone usage in interactions between parents and children. Research on the topic of technoference in parent-child interaction due to caregivers' smartphone use suggests that such disruptions may have numerous adverse effects on children's mental health (McDaniel & Radesky, 2018a, 2018b; Merkaš et al., 2021). These effects are most explained by the displacement hypothesis (Valkenburg & Peter, 2007) in the literature, according to which excessive smartphone use can contribute to communication breakdown in the family. When parents are focused on smartphones, effective communication with their children may

suffer as well as daily routines and boundaries, hindering the development of a strong parent-child bond. Interventions focused on embracing and learning adaptive emotional regulation strategies, primarily negative emotional states, can not only reduce the risk of smartphone addiction but also contribute to creating a richer and more focused environment for parent-child interactions. Hence, in the light of prevention, it is important to explore predictors and risk factors for technology interference in the family context.

Limitations and future directions

While the present study offers valuable insights into the association between emotion regulation challenges, the risk of smartphone addiction, and technoference in parent-child interaction, it is important to acknowledge several limitations.

Firstly, this study is conducted with a sample of Croatian parents who willingly took part in the study and were invited to participate. Derived from the sociodemographic attributes of parents and children, the conclusions from this study predominantly pertain to families belonging to the middle to upper socio-economic strata. In such settings, technology interference, as reported by parents, occurs rarely, indicating a context where familial interactions are less disrupted by smartphones. This highlights the necessity for future exploration of the observed effects in families with varying levels of functionality and diverse socioeconomic backgrounds. What is more, considering that most of the sample in this study consisted of mothers (80.9%), a recommendation for future research is to include more fathers in the sample.

Second, in the current study, the DERS-16 (Bjureberg et al., 2016) was used, specifically designed for assessing difficulties in regulating unpleasant emotions. As a suggestion for future research in this field, it would be interesting to incorporate additional aspects of emotion regulation, such as maladaptive internal and external strategies, the use of adaptive strategies of emotion regulation, etc.

Third, while our initial hypothesis and examination focused on the indirect effect of the risk of smartphone addiction, it would be prudent to explore potential mediating roles of some other characteristics, such as parenting styles or dimensions of parenting in future research. It is also probable that certain characteristics in children, such as challenging children's temperament, may influence parents' mobile use. So, future research should include some dispositional traits of both children and parents given that a child's development is shaped by the interplay between the child and their environment, including parents.

CONCLUSIONS

The findings of the study support the hypothesis about the mediating role of the risk of smartphone addiction in the relationship between difficulties in emotion regulation and technoference in parent-child interactions. Parents, mainly mothers from middle to upper-socioeconomic families, who experience higher emotion regulation difficulties are at a higher risk of smartphone addiction. This, in turn, is associated with more frequent interruptions of

parent-child interactions. The study results indicate that difficulty in emotion regulation does not have a direct effect on technoference in parent-child interactions.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

The ubiquity of smartphones every day has resulted in disruptions in social interactions, transforming what was once considered an occasional interruption into a socially acceptable norm (Stockdale et al., 2018). As smartphones become more pervasive within family environments, problems may arise, especially in households where these interruptions occur frequently (Meeus et al., 2021; Stockdale et al., 2018). The normalization of these disruptions poses a question on the long-term effects on familial relationships and underscores the importance of establishing clear boundaries for digital device use to maintain healthy relationships. To address the latter question, a proposal for future research is a longitudinal examination of the specificities of family functioning in the context of technoference and its associations with mental health outcomes in parents and children.

Research on technoference in parent-child interaction due to parents' smartphone use suggests that such disruptions have numerous adverse effects on children's mental health. This research focuses on parents' difficulties in emotion regulation and problematic smartphone use in the context of technoference in the parent-child relationship. Prevention activities focused on embracing and learning adaptive emotional regulation strategies, can not only reduce the risk of smartphone addiction but also contribute to a richer environment for parent-child interactions.

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NON-IMMERSIVE FORMS OF VIRTUAL REALITY (NIVR) AND ATTITUDES TOWARDS TRAVEL DESTINATIONS IN THE ERA OF COVID-19 SELF-ISOLATION

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Abstract: *The main aim of this paper is to investigate the relationship between the attitudes towards virtual reality tools and the expected attitudes towards destinations selected during the self-isolation period resulting from the global pandemic caused by COVID-19. The study employs a research model based on the modified and extended Technology Acceptance Model, with structural modelling applied for verification purposes. The measurement criteria are mostly adopted from previous research or developed by the authors. Findings indicate that VR tools are perceived as easy to use, which directly affects the perceived enjoyment and usefulness of the VR. Furthermore, virtual reality tools are perceived as more useful when there is no alternative means of experiencing the external (real) world. The research model also confirms that the cognitive component of the users' attitude directly influences their behaviour, whereas the affective dimension is not significant. This indicates that non-immersive VR tools and materials are perceived primarily as a conduit for disseminating pertinent information and providing the opportunity to compare destinations and make more informed decisions. In addition to these practical findings, this paper also contributes to this research strand by considering the influence of the COVID-19 pandemic on the acceptance of virtual reality (VR). Finally, the proposed model further extends the TAM to different attitude aspects, such as behavioural, cognitive and affective components.*

Keywords: *Virtual Reality, non-immersive VR, destination, COVID-19, tourism, consumer behaviour*.

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INTRODUCTION

The Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), known as COVID-19, discovered in December 2019 in Wuhan, China, was declared a pandemic by WHO on March 11, 2020. By April 2022, the number of cases worldwide reached 289,471,418, with 6,179,531 confirmed deaths (John Hopkins COVID-19 Resource Center, 2022).

In the event of an epidemic, the most effective means of preventing the transmission of the disease include self-isolation and lockdowns, quarantine, and social distancing (Florek & Lewicki, 2022). The consequences of the Coronavirus Disease 2019 (COVID-19) pandemic have been far-reaching, affecting nearly every aspect of life and business (Fernandes, 2020; McKibbin and Fernando, 2020; Tovmasyan, 2023). The Travel and Tourism (T&T) industry has been particularly hard-hit (UNWTO, 2020a).

A notable consequence of the SARS-CoV-2 pandemic is a transformation in human behaviour and consumption patterns, including alterations in mobility preferences due to the associated risks of travel. The latter are among the most significant factors influencing the decision to travel in general, as well as the selection of specific destinations (Rittichainuwat and Chakraborty, 2009; Garg, 2015; Sarkady et al., 2021). In response to the growing consumer anxiety and uncertainty, there has been a significant increase in the utilisation of alternative forms of access to destinations. VR is gaining momentum in this context, as it enables users to explore virtually by manipulating computer-generated images or videos, thereby simulating real-life experiences and even offering an alternative to travel (Guttentag, 2010; Loureiro et al. 2020). Furthermore, it enables users to virtually "visit" the most remote locations on Earth (Sarkady et al. 2021). Both industry statistics and researchers suggest that VR has great potential in situations where a real-life experience is challenging to attain (Lee and Kim, 2021).

According to World Tourism Organization (2020), SARS-CoV-2 pandemic has in fact created opportunities for destinations to prioritize innovation, particularly in the digital domain. In the context of the global pandemic, there has been a growing necessity to engage with visitors virtually, given the unavailability of other options, with the aim of providing information, delivering experiences, and eliciting positive sentiments towards destinations and specific tourist attractions (Yung et al. 2021). Consequently, the UNWTO Secretary-General, Zurab Pololikashvili, stated: “We now have an opportunity to rethink tourism and do things better. Virtual reality, artificial intelligence, and big data will all have a part to play in our joint response to COVID-19, and in building resilience for the future” (UNWTO, 2020b).

It is important to note that virtual reality (VR) can be categorised into different forms. Non-immersive VR (niVR) systems represent the simplest and most readily available options, and therefore the most common (Carrozzino and Bergamasco, 2010; Dörner et al., 2013). A conventional computer screen is sufficient to simulate a three-dimensional space, allowing the participant to observe and interact with it (Dörner et al., 2013; Liu et al., 2016). In literature gaps can be found which relate to the dimensions of consumer behaviour and their experience with VR (more in Yung et al. 2020). COVID-19 appears as a subject of the latest research but primarily as the background for ongoing discussions. Concurrently, these novel circumstances may exert a considerable influence on the manner in which individuals assess VR technologies and the potential impact of VR on their attitudes towards destinations.

The goal of this paper is therefore to investigate the relations between the attitudes towards virtual reality tools and the expected attitudes towards the destinations which apply them, in

self-isolation caused by COVID-19. The research model is based on the Technology Acceptance Model (TAM), as proposed by Davis (1989), which has been modified and extended in order to achieve the objectives of the study.

The premise of the present study is that, in the new pandemic context, people might want to use VR forms more often and, preferably, it might influence their attitudes (cognitive, affective and behavioural) towards destinations. In instances where individuals are unable or unwilling to travel to crowded locations and seek experiences with minimal human interaction, virtual reality (VR) technology provides an avenue for engaging in such experiences without the necessity of physical presence (Buhalis and Motloka, 2013; Zakrzewski et al., 2022). This potential persists even after the completion of self-isolation (Mohanty et al., 2020). In light of the significant shift in consumer behaviour and activity from traditional, face-to-face settings to digital, online environments, it is imperative to conduct a comprehensive examination to gain a deeper understanding of tourist behaviour (Lee et al., 2021) and its implications for destinations.

Specifically, the study aims to:

- determine the influence of the COVID-19 pandemic on the acceptance of virtual reality (perceived usefulness, perceived ease of use, perceived use enjoyment),
- determine the impact of niVR usage on the cognitive component of destination attitude in the era of COVID-19
- determine the impact of niVR usage on the affective component of destination attitude in the era of COVID-19
- determine the effect of niVR usage on the behavioral component of destination attitude in the era of COVID-19.

LITERATURE REVIEW

Virtual Reality

Virtual reality (VR) can be defined as a set of images and sounds produced by a computer that simulate the experience of a real place or situation (dictionary.cambridge.org). The conceptual manifestations of virtual reality have a history that can be traced back to the late 1920s, as evidenced by The Link "Blue Box" Trainer Flight Simulator (McFadden, 2018). Thompson (2017), on the other hand, posits that the birth of virtual reality can be traced back to the mid-19th century with the invention of stereoscopes.

The thematic scope of publications about VR is extensive, encompassing a multitude of disciplines, including military applications (Lele, 2013), medical applications (Goo et al., 2020), gaming (Viitanen et al., 2018) and tourism (Schiopu et al., 2021; Flavián et al., 2021). The tourism sector has recently attracted the greatest interest, largely due to the global restrictions imposed by the Coronavirus Disease 2019 (Covid-19) pandemic (Florek & Lewicki, 2022). Conversely, the term is also the subject of criticism, with calls for a unified definition (Kardong-Edgren et al., 2019) and concerns that it is being stretched too far (Laurel, 2016). For the purpose of this study, the term 'VR' is defined as follows: “A computer-generated display that allows or compels the user (or users) to have a sense of being present in

an environment other than the one they are actually in and to interact with that environment" (Schroeder, 1996, p. 25).

In his 2013 study, Mandal posited that virtual reality (VR) systems can be classified into three categories based on the level of immersion they offer:

- Non-Immersive (Desktop VR) systems – in spite of the name suggesting fully non-immersive option, they do represent a low level of immersion and as such do not require employment of any special or complicated devices in application.
- Semi-Immersive (Fish Tank VR) systems – are an improved version of Non-Immersive systems, supporting head tracking; these systems improve the feeling of presence.
- Immersive systems – can be seen as the ultimate version of VR systems, allowing total immersion in the virtual world with the help of dedicated devices including dedicated audio, haptic and sensory interfaces.

Non-immersive virtual reality (VR) systems represent the most prevalent, straightforward, and accessible means of accessing VR applications (Gutiérrez et al., 2008; Carrozzino and Bergamasco, 2010; Dörner et al., 2013). In addition to computer games, non-immersive virtual reality is exemplified by 360° environments, wherein users can view 360° content (e.g., city panorama) by moving or rotating the device (e.g., PC, tablet, or smartphone) on which the content is played. (Repetto et al., 2018). This solution is now widely employed, for instance in the field of tourism, where it takes the form of so-called "virtual tours" (El-Said and Aziz, 2021; Bilan et al., 2024).

Measurement of attitudes towards technology

The use of information and communication technology (ICT) expands constantly to new sectors of the economy since the late 1980s and is naturally accompanied by numerous studies on the acceptance of the technology by users (Swanson, 1988; Davis, 1989; Thompson, Higgins, Howell, 1991). One of the oldest and most frequently used models of technology acceptance is the TAM (Technology Acceptance Model) introduced by Davis (1989) in 1989.

The origin of the TAM are the principles adopted from Fishbein and Ajzen's (1975) attitude paradigm. Since its introduction, countless variants have emerged across a variety of scientific disciplines. The TAM was criticized by the scientific community (e.g. Chuttur, 2009; Bagozzi, 2007) for its triviality and flexibility which, in a sense, led to theoretical chaos. Nevertheless, it is owing to the aforementioned features that a lot of interesting research into this topic has been possible and conducted (Wang et al., 2003). There is no perfect model to measure the users' attitudes towards technology and each of technology acceptance theories has some weaknesses (Riffai et al. 2012). Yet, a review of literature clearly shows that the TAM continues to be the starting point for many contemporary studies (e.g. Vahdat et al., 2021; Yuen et al., 2021). The tourism industry is no exception. The latest research in this industry, based on the extension of the TAM, covers a very wide spectrum of issues related to the ICT, e.g.: the attitude and behaviour toward using the DCM (Digital Content Marketing) for tourism purposes (Mathew, Soliman, 2021); the attitude and behaviour toward using the Internet to search for information related to eco-tourism (Sadiq and Adil, 2021) etc.

Despite the fact that the TAM has been commonly modified and extended over the years, most of these changes focused on the left side of the model, often leaving its right side completely unchanged (Figure 1).

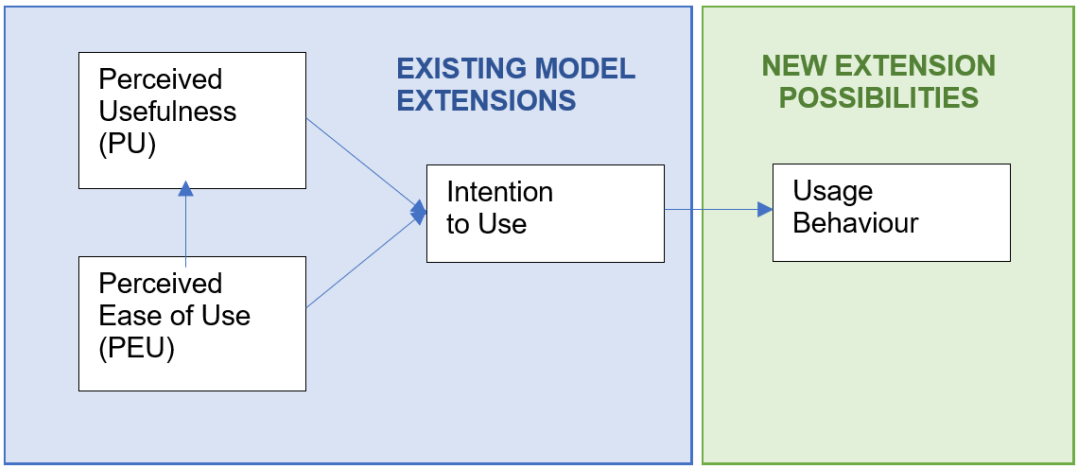

Figure 1. The focal point for changes to the Technology Acceptance Model.
Source: Own work based on Davis, 1989.

Starting with the updated version of TAM (i.e. TAM2 that extended the model with external variables affecting PU and PEU (Venkatesh and Davis, 2000)) and the Unified Theory of Acceptance and Use of Technology (i.e. UTAUT which introduced four key constructs determining usage intention and usage behaviour (Venkatesh et al., 2003)), most of the later extensions (including all of the aforementioned TAM modifications in tourism) followed the pattern by incorporating more and more external variables to serve a purpose of a given study. This creates a clear cognitive gap for any future iterations of the model. For the purpose of the current research, the original TAM was used as a source of inspiration and a starting point for further modifications.

Measurement of attitudes towards destinations

According to the most applied definitions, attitudes are personal evaluative reactions to socially relevant issues concerning specific objects, events, people, contexts and/or behaviours (Passafaro, 2020). Fishbein and Ajzen (1975) understand attitudes as learned predisposition to responding in a consistently favourable or unfavourable manner with respect to a given object. Eagly and Chaiken (1993, p.1) define attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour". The evaluation statements can be therefore either favourable or unfavourable, as they reflect how one feels about something (Robbins, 2010). In tourism, attitude is commonly understood as the tourists' predisposition or feelings toward a destination and related services, which is based on perception of tourism products and attributes of the destination (Pereira et al. 2019).

The Theory of Planned Behaviour deals with the nature of behavior-specific factors that are designed to predict and explain human behaviour in specific contexts (Ajzen, 1991). In the destination context, the Theory proposes that a tourist's behavioural intentions are formed based on their attitude, social norms and perceived behaviour controls towards visiting a destination (Fishbein and Ajzen, 1975). Tourism scholars have applied the Theory to study attitude as a determinant of behavioural intentions of choosing a destination. Based on the

literature review, Hadinejad et al. (2021) conclude that previous research confirmed the significant impact of attitude towards a destination on intention to visit. It is important to note, however, that although the Theory is the most commonly applied theoretical framework to explore visitors' attitudes towards tourist destinations, it has been criticized regarding their inability to address the affective aspect of attitude formation. As such, the Cognitive Response Theory considers the role of the valence of thoughts (favourable or unfavourable) in influencing attitude. The elaboration likelihood model and heuristic systematic model discuss the amount and valence of thinking as determinants of attitude, and highlight the cognitive and affective aspects of attitude formation (see Hadinejad et al. 2021).

Attitude should be therefore analysed according to the three components (Eagly and Chaiken, 1993): cognitive, affective, and behavioural. The cognitive response is the evaluation made on the basis of information and knowledge about a destination; it is comprised of thoughts (often conceptualized as beliefs) about the attitude object. The affective response is the evaluation of the destination made on the basis of feelings, moods and, emotions of the tourists. The behavioural (conative) component is a tendency or disposition to act in certain ways toward a destination.

As Pearce and Packer (2013) suggest "the attitudes tourists hold towards the people and places visited are not fixed and standard entities but shifting, socially negotiated communications" (p. 391). In the COVID-19 situation, it is an important consideration as attitudes might be context dependent (Pearce and Packer, 2013).

RESEARCH METHODOLOGY

Based on the literature review on VR and its use in tourism to date, the following research model has been proposed (Figure 2). It should be noted that in the past two years, there has been a big upsurge of publications on both VR and the COVID-19 pandemic, especially in relation to tourism. While there is a stream of research signaling the importance of VR use in tourism during the pandemic, it focused primarily on the acceptance of the VR itself. The model presented in Figure 2 is a step forward and is meant to measure the influence of VR use in tourism (in its most accessible non-immersive form) on the attitudes of the system's users towards destinations. It should be noted that this impact will be examined in relation to three elements of attitudes, which fills the existing research gap.

Although extending the TAM model with external factors is not a novel concept, extending it towards its consequences, such as attitudes, can be considered a significant contribution to the field. The fundamental structure and the relationships between its components have remained consistent in relation to its prototype since 1993. Regarding the external factors, the influence of the COVID-19 pandemic perspective (COV) on technology (VR in general) acceptance is taken into consideration. Moreover, we have decided to add an element of intrinsic motivation - Perceived Use Enjoyment (PUE) included in previous studies by Teo et al. (1999) as a potential significant factor during the pandemic. The proposed model further extends directly to the attitude aspect, consequently including: the Behavioural Component (BC), the Cognitive Component (CC) and the Affective Component (AC).

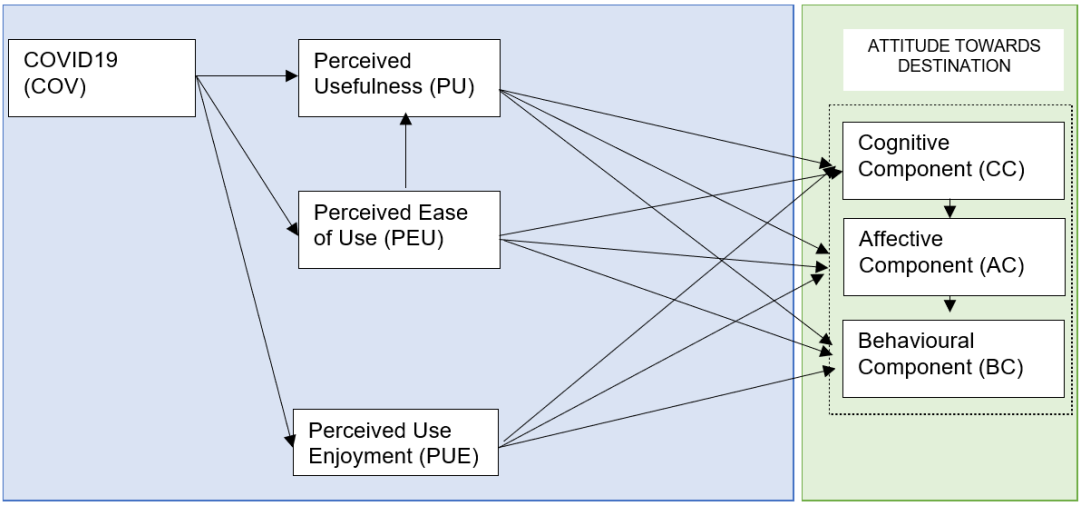

Figure 2. The research model.
Source: Own research.

The method applied to verify the research model was structural modelling. The items used to measure the relevant constructs were mostly adopted from literature on the subject and several developed by the authors (Table 1). In the research process, the respondents were asked to refer to a number of statements on a 7-point Likert scale.

Table 1. Items measuring model constructs.

CONSTRUCT	ITEM	SOURCE
PERCEIVED USEFULNESS	Using VR applications in tourism is a good idea.	Schiopu et al., 2021
	I think VR is useful for travel planning.	Disztinger, Schlögl and Groth, 2017
	I think VR offers access to accurate and reliable information about destinations at a fraction of the cost, time and effort compared to traditional promotional material.	Buhalis, 1998
PERCEIVED EASE OF USE	Learning to operate VR was easy for me.	Disztinger, Schlögl Groth, 2017
	I find VR easy to use.	Hong, Thong, Tam, 2006
PERCEIVED USE ENJOYMENT	I find using VR enjoyable.	Disztinger, Schlögl Groth, 2017
	I have fun using VR.	Disztinger, Schlögl Groth, 2017
	Using VR is pleasant.	Disztinger, Schlögl Groth, 2017
COGNITIVE COMPONENT	The (niVR) material provided me with reliable information in a fast and convenient way about a destination.	Rainoldi et al., 2018
	After seeing (niVR) material I feel I know more about a destination.	Own work
	The (niVR) material provided me with a richer visual and auditory experience about a destination.	Durlach, Mavor, 1995
EMOTIONAL COMPONENT	The (niVR) material and presented within it destination touched on and induced emotions.	Rainoldi et al., 2018
	I found watching the (niVR) material presenting the destination pleasant.	Carù, Cova, 2006; Riva et al., 2007; Jennet et al.,2008; Hansen, Mosberg, 2017; Lee, Kim, 2021

	I found watching the (niVR) material presenting the destination relaxing.	(Carù, Cova, 2006; Riva et al., 2007; Jennet et al.,2008; Hansen, Mosberg, 2017; Lee, Kim, 2021
	After experiencing the (niVR) material, my desire to visit the destination is stronger.	Lee, Kim, 2021; Rainoldi et al., 2018
BEHAVIOURAL COMPONENT	After experiencing the (niVR) material, I am willing to recommend visiting the destination.	Rainoldi et al., 2018
	After experiencing the (niVR) material I'm willing to recommend the material to my friends.	Own work
	I think VR tools are useful in the pandemic.	Own work
COVID-19 PERSPECTIVE	VR tools can be more enjoyable in the pandemic.	Own work
	VR tools can help me with psychological and mental pressure in the pandemic.	Yang et al. 2021

Source: Own research.

During the survey, after responding to the questions on the COVID-19 situation and opinions on VR technology, the respondents were asked to use niVR material - a virtual tour of Dubai (reflecting at the same time the very actual use of VR which is included in the original TAM). After using the tool, they could answer the next part of the survey which related to attitudes towards a destination.

Data have been collected between 4 and 21 October 2021 via an online questionnaire completed by individuals with any type of experience with the VR technology (e.g. gaming) via tourism-related Facebook groups and forums (74 global and regional groups and 7 forums were selected). During the data collection, in most cases FB banned the invitation to participate in the survey (with 8 groups and 2 forums left) therefore the Amazon Mechanical Turk platform was used to complete the research sample (among individuals who met the same requirements). This resulted in the sample size of 386 (391 questionnaires were collected, but 5 were eliminated as incomplete) with respondents from 40 countries.

The respondents were asked to specify their gender, age, nationality (categorised later according to the world region), the education level, marital status, the mode of working during the pandemic (online, face to face, hybrid) and travel experience during COVID-19 (see Table 2 for sample characteristics). These characteristics have been used for detailed analyses that are beyond the scope of this paper and the main focus of the discussion (they have been presented in Florek, Lewicki, 2022).

Table 2. Sample characteristics, N=386.

Characteristic	Percentage of overall answers
GENDER	
Female	42.5
Male	54.4
Refuse to answer	1.8
REGION	
Asia	18.9
Europe	27.7
USA	42.2
others	6.2
AGE	
18-25	27.7
26-35	39.9
36-45	21.0
46-55	6.5
Over 55	4.7
MARITAL STATUS	
Married	57.3
Single	40.9
EDUCATION LEVEL	
Master or above	29.3
Bachelor	49.0
Engineer	7.8
Secondary	11.7
Primary or below	1.6
WAY OF WORKING DURING COVID-19	
Fully online	60.9
Hybrid	19.2
Face to face only	9.1
Combination of above	10.1
TRAVEL BEHAVIOR IN PANDEMIC	
I have travelled during the pandemic	69.2
I have not travelled during the pandemic	30.6
I plan to travel during the pandemic	72.0
I don't plan to travel during the pandemic	27.2

Source: own research.

As presented in Table 2, the majority of respondents were male (54.4% of men compared to 42.5% of women). The vast majority (42.2%) are residents of the United States, followed by representatives of European and Asian countries. The largest cohort of respondents was comprised of individuals aged 26-35, representing nearly 40% of the total sample. The proportion of respondents in the 46-55 and over 55 age groups combined constitutes only slightly over 11% of the total surveyed population. Almost 90% of respondents had obtained a higher education qualification. During the period of the pandemic, over 60% of respondents indicated that they were employed exclusively in an online capacity, while less than 10% reported that they were engaged in face-to-face work. It is also noteworthy that nearly 70% of respondents engaged in travel activities during the pandemic, either as actual travelers or as individuals with planned travel.

RESEARCH RESULTS

Construction of the structural equation model started with building a measurement model (Figure 3). To this end, Confirmatory Factor Analysis (CFA) was used that makes it possible to check the relations between observable indices and latent factors. The model's parameters have been calculated by means of Maximum Likelihood (ML); AMOS software has been used to model the structural equations. In the ultimate version, the variables with the smallest factor loads were excluded from the measurement model. When removing the data, modification indices were also taken into account together with the requirement of describing each hidden variable by at least three observable indicators for the structural model to be identifiable.

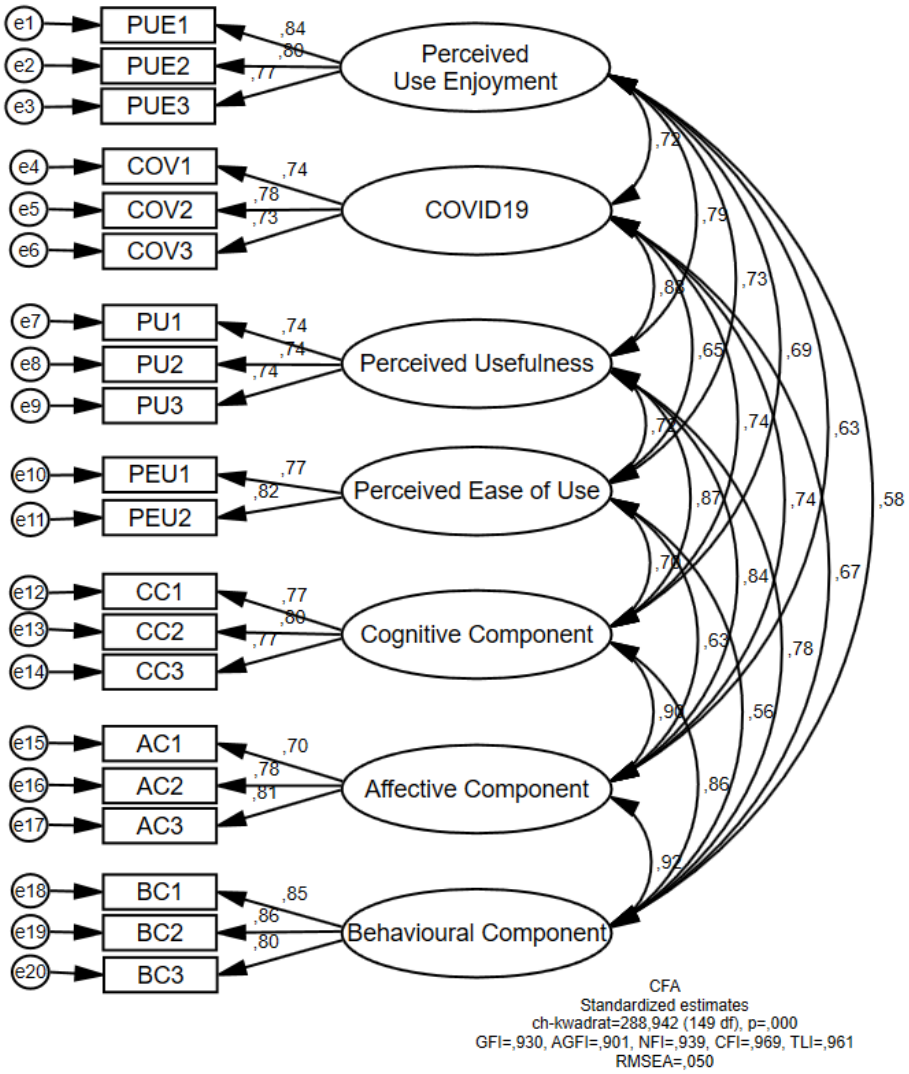

Figure 3. The measurement model.
Source: Own research.

All the factor loads are statistically relevant and exceeding 0.7. The evaluation of the quality of the measurement model of the seven hidden variables and twenty observable indicators has been done by means of a number of measures of the goodness of fit model i.e. CMIN/DF = 1.939; RMSEA = 0.05; GFI = 0.93; NFI=0.939; the IFI= 0.97 CFI=0.969 AGFI=0.901 and the PGFI=0.66, which indicates a model's acceptable fit.

Finally, the convergent validity was evaluated of the measurement of the theoretical constructs. On the basis of the AVE and CR indices, high homogeneity of elements of the measuring scales can be acknowledged (PUE, COV etc.) (Table 3).

Table 3. Evaluation of the reliability of measurement of hidden variables.

Hidden (latent) variable	Questionnaire statement (observable index)	Standardised loading (λ)*	α	AVE	CR
PUE	F19_I_have_fun_using_VR	0.798			
PUE	F18_I_find_using_VR_enjoyable	0.840	0.84	0.65	0.85
PUE	F20_Using_VR_is_pleasant	0.774			
COV	B4_VR_tools_can_be_more_enjoyable	0.775			
COV	B2_I_think_VR_tools_are_useful_in	0.735	0.79	0.56	0.79
COV	B5_VR_tools_can_help_with_psychol	0.726			
PU	D13_I_think_VR_is_useful_for_trave	0.740			
PU	D12_Using_VR_applications_in_touri	0.737	0.77	0.55	0.78
PU	D14_I_think_VR_offers_access_to_ac	0.738			
PEU	E16_Learning_to_operate_VR_was_eas	0.767	0.78	0.63	0.77
PEU	E17_I_find_VR_easy_to_use	0.819			
CC	H32_After_seeing_VR_material_I_fee	0.798			
CC	H31_The_VR_material_provided_me_wi	0.770	0.82	0.61	0.82
CC	H33_VR_material_provided_me_richer_visual	0.769			
AC	I37_I_found_watching_the_VR_materi_pleasant	0.785			
AC	I36_The_VR_material_touched_on_and	0.703	0.73	0.59	0.81
AC	I38_I_found_watching_the_VR_materi_relaxing	0.813			
BC	J43_After_experiencing_the_VR_mate_recommend	0.855			
BC	J42_After_experiencing_the_VR_mate_visit	0.849	0.87	0.70	0.87
BC	J45_After_experiencing_the_VR_mate_material	0.801			

*p< 0.001
Source: Own research.

On the basis of the research model and the results, the structural model has been specified as presented in Figure 4.

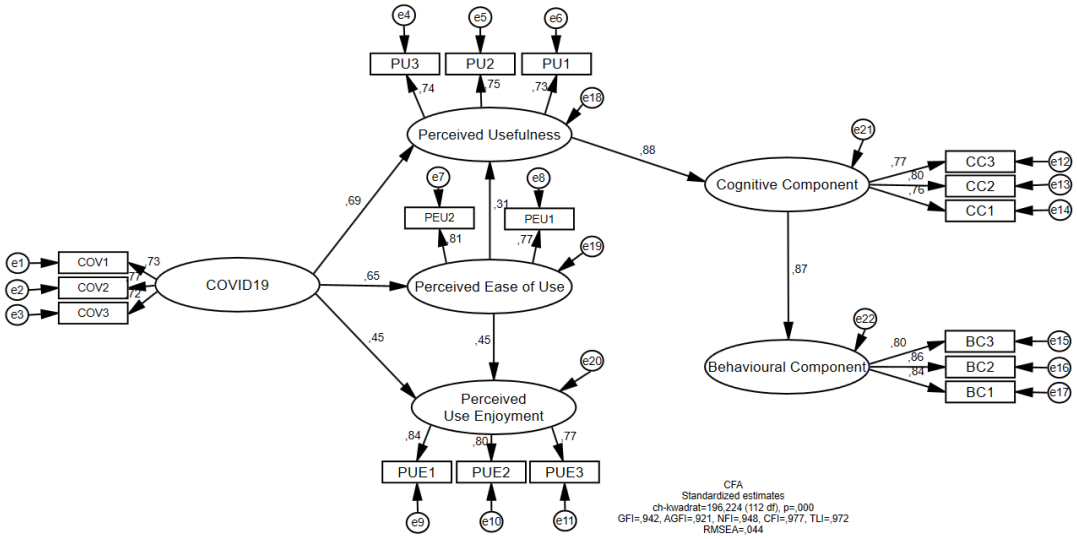

Figure 4. The structural model.
Source: Own research.

The model presents good fit with the data i.e.: CMIN/DF 1,752; GFI 0,942; AGFI 0,921; NFI 0,948; RFI 0,937; IFI 0,977; TLI 0,972; CFI 0,977.

As a result of the work, the following statistically significant relationships are extracted from the model:

1. the COVID-19 pandemic affects: a. perceived usefulness of VR; b. perceived ease of use of VR; c. perceived enjoyment of VR
2. perceived ease of use of VR affects: a. perceived usefulness of VR; b. perceived enjoyment of VR
3. perceived usefulness of niVR affects the cognitive component of attitudes toward the destination
4. the cognitive element of attitudes influences the behavioral element of attitudes toward a destination.

No statistically significant relationships were found for the other elements. Thus, the perceived ease of use of non-immersive forms of VR and enjoyment of niVR do not directly influence attitudes toward destinations in the pandemic. Simplifying the findings, it can be concluded that niVR is primarily evaluated as a useful tool (during pandemic-induced isolation) that influences cognitive (rather than emotional) processes, which in turn influence behaviours toward destinations (such as intension to visit or recommendations).

DISCUSSION

Based on the presented research, we can conclude that an external factor i.e. COVID-19 perspective (COV) and an intrinsic motivator i.e. Perceived Use Enjoyment (PUE), are both significant TAM extensions. There is a positive and relatively strong correlation between the external condition which is the pandemic (COV) and both original TAM elements such as Perceived Usefulness (PU) and Perceived Ease of Use (PEU) of VR (in general). Therefore, it can be concluded that the pandemic indeed has a positive effect on people's perception of VR within both elements. Similarly, COV influenced Perceived Use Enjoyment (PUE), however, the intensity of this influence was lower. In the case of PUE, no direct or statistically significant correlation was found between PUE and the components of attitude towards destination (i.e. the assumption of the conceptual model has not been confirmed). Nevertheless, it should be emphasized that this factor is related to the aforementioned COV and PEU, where it is positively influenced by both factors. In the case of PEU's influence on PUE, it should be noted that it confirms previous studies carried out by Teo et al. (1999) as well as van der Heijden (2004). Notably, while in some of the previous studies on the TAM there was a positive correlation between PUE which influenced PU and PEU (e.g. Mun, Hwang, 2003; Mujiyati and Achyari, 2009; Ha and Stoel, 2009), no such correlation was found in our research. The correlation between the PEU and PU variables from the original TAM was confirmed, where PEU positively influenced PU (Davis, 1993). In relation to the research model, no direct relationship was found between PUE and the components of attitude towards a destination, while in the case of PU, a direct influence of this factor was found only for the cognitive component of attitude (CC). It should be noted, however, that in relation to PU, there is an indirect relationship also with the behavioral component of the attitude (BC), since a direct influence of CC on BC was found.

The findings of the research indicate that the majority of users perceive virtual reality (VR) tools to be straightforward to use, which subsequently impacts their overall enjoyment and perceived usefulness of the VR technology. The limited possibilities available during periods of self-isolation have a positive influence on each of the three constructs (namely PUE, PU and PEU), with the strongest correlation observed between the perceived usefulness (PU) of VR. It can be reasonably assumed that the utility of VR tools is perceived to be greater when there is no alternative means of experiencing the external (real) world.

Proceeding with the other side of the model, the attitudes towards destinations influenced by specifically niVR were investigated to analyse the potential effect of actual use of the tool. While the cognition-affect-behaviour structure of attitude has been accepted as a useful framework, there is a strong line of research that regards attitudes as having cognitive and affective dimensions that affect one's behaviour (Kim and Stepchenkova, 2015). In the aforementioned study, which investigated non-immersive forms, it was found that the cognitive component (CC) directly influences the behavioural component (BC) of users. The content had a positive effect on the respondents, who were more willing to recommend the destination, visit it again, and recommend the niVR material itself. The affective dimension (AC) was found to be of lesser importance, potentially due to the fact that it is immersive forms that facilitate users having a more realistic tourism experience in their desired location, thereby eliciting a stronger emotional response (Brooks, 1999; Parés and Parés, 2006). The significance of the cognitive dimension indicates that non-immersive VR tools and materials are primarily regarded as a

means of imparting pertinent information. Furthermore, the capacity to evaluate various destinations facilitates more judicious decision-making, a notion previously postulated by Cheong (1995). In particular, during the pandemic, niVR has the potential to serve as an accessible and attractive source of knowledge about destinations. This view is supported by Chiou et al. (2008) and Borawska et al. (2023) who consider virtual experiences as advertisement more efficacious than conventional marketing tools increasing the effectiveness of persuading to visit (Huang et al., 2016). And as our research confirms, niVR tools do affect the willingness to visit. It is, however, important to note that we consider the special conditions caused by COVID-19, as in general, VR is perceived as a useful tool in self- isolation, influencing CC of attitudes, and then BC.

CONCLUSIONS

It is predicted that virtual travels might increase in the post-COVID-19 era. Destinations will promote their places and travel companies will offer their services via virtual tools before the real experience (Atsız, 2021, Florek, Lewicki, 2022). As VR technology can reduce the physical distance between potential tourists and a destination (Leung at al., 2020), the emotional one is also minimalized.

With the research results, it might be expected that after the pandemic, the familiarity and experience with VR gained during the COVID-19 years, will result in a tool used as a significant source of destination knowledge (in the case of non-immersive forms), influencing people's behaviours toward destinations. Even if this was only the first step – behavioural declaration to actual behaviour - the tool is worth applying on a continuous basis.

The presented research has some limitation. First, it focuses only on non-immersive forms of virtual reality. On the one hand, we consider niVR the easiest for destinations to implement and for users to handle, they do pose some limitations when it comes to creating more emotional-based environments. Immersive VR forms as a subject of research would probably highlight a more affective attitude towards destination and therefore need separate investigation. Secondly, there is always a risk in interpretation of what VR stands for to the respondents. This weakness has been addressed in our study by real usage of niVR, however the general opinions on VR among the respondents might present some bias. In addition, different niVR material or a different destination as a survey case could result in different attitudes. It is important to acknowledge that the composition of the studied population represents a potential limitation to the generalizability of the findings. The study population was predominantly male, comprised of US residents, and was relatively young (i.e., under 35 years of age). Additionally, the population included individuals who were traveling and planning a trip despite the pandemic-related restrictions. It can be posited that an alternative population structure, for instance one comprising a greater proportion of women or older individuals (i.e. aged 55 and above), would yield novel insights from the study.

IMPLICATIONS FOR RESEARCH, APPLICATION AND POLICY

In light of the aforementioned research's conclusions and limitations, it is evident that there are avenues for further investigation on this topic. For instance, valuable data could be obtained by conducting a survey of two groups and observing different niVR material to facilitate a comparison of the results. Further studies should also examine the real impact of self-isolation and niVR on attitudes toward a destination after freedom of travel was restored.

Furthermore, it can be concluded that VR represents an intriguing potential for destination managers and entrepreneurs seeking to enhance and enrich consumer experiences. Consequently, it can be considered a reliable investment for the future by organizations and companies within the tourism industry.

Finally, it can be expected that familiarity and experience with VR gained during COVID-19 will make VR (and similar virtual tools) a regular source of destination knowledge influencing people's behaviour toward destinations. Destinations should therefore take these considerations into account when designing their strategies and selecting appropriate communication tools.

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THE FUTURE OF ARTIFICIAL INTELLIGENCE: FEAR, HOPE OR INDIFFERENCE?

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Abstract: *The article explores how youth perceive the risks of artificial intelligence (AI), based on a survey of 410 university students from Poland, Spain, and Ukraine. The study confirms non-random responses with acceptable internal consistency for categorical variables and complex constructs. The authors built three latent profiles of participants with pragmatic, skeptical, and cautious attitudes towards AI. The scenario approach revealed that respondents are cautious about the use of AI but generally support its implementation under conditions of flexible state regulation. Youth do not see AI as a threat to social equality or the labor market but expect state support through retraining and basic income for laid-off workers. At the same time, there are both optimistic and skeptical scenarios about the future of AI, which depend on the level of awareness and cultural characteristics of the respondents.*

Keywords: *artificial intelligence, dominant scenario, latent profile, risk, threat.*

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INTRODUCTION

Industry 4.0 and 5.0 have caused dynamic and fast-paced development of information and computer technologies in various spheres of society. This has led not only to the acceleration in computer capabilities but also to a decrease in computer price and an increase in accessibility to all population segments. In addition, the use of artificial intelligence (AI) to solve various economic and business problems is becoming widespread. For example, the market for AI-based software in 2016 amounted to $8 billion (Lohr, 2016). By June 20, 2024, however, the AI market was already equal to $184 billion, which is 23 times more than in 2016 (Statista, 2024). At the same time, Statista (2024) predicted its growth to $826 billion in 2030, which is 103.25 times more than in 2016 and 4.5 times more than in 2024. Frank Gens, the chief analyst of IDC research company, said that everyone is now headed for the moment when AI is everywhere (Lohr, 2016). This confirms the spectacular growth of the AI market.

Although artificial intelligence has been known since 1956, when John McCarthy coined the term during the Dartmouth Seminar, some professionals consider the beginning of its active and powerful phase to be 2022-2024, when scalable language models such as ChatGPT were developed and implemented (Marr, 2023). Given this activity, concerns are being raised over any risks from AI for humanity. However, many remain convinced that this problem is far-fetched. For example, 97% of business owners are optimistic about the use of AI in their operations and believe that it will contribute to their development, but 43% of them are concerned about becoming too dependent on AI (Haan & Watts, 2023). In addition, 77% of employees are concerned that AI could lead to job losses (Haan & Watts, 2023). According to McKinsey, there is a risk of displacement of 400 million workers due to artificial intelligence (Manyika & Sneader, 2018). Also, Jeffrey Hinton, the "godfather of artificial intelligence", warns about the existence of risks from AI, namely technological unemployment, abuse by malicious actors, as well as existential risks, when progress in AI can lead to human extinction (Jacobson et al., 2023).

Automation and the introduction of AI have already affected the existence of certain professions. For example, robotization has replaced workers in automotive and electronic production. The introduction of electronic self-service counters has reduced the number of cashiers in stores and banks. More and more companies prefer to use chatbots instead of maintaining fully functional call centres. Autonomous vehicles are being introduced in cargo transportation. AI is also affecting such professions as financial analysts, medical diagnosticians, and content writers.

AI has been actively used to solve military problems, which, on the one hand, has increased their efficiency and reduced the cost of their implementation. On the other hand, this has serious negative consequences for the civilian population, moral principles, and the international community. We are talking about the risks of making decisions to destroy targets without human intervention, the use of cyber weapons to hack critical infrastructure, escalation of conflicts through diplomatic fakes and disinformation, erroneous military actions as a result of errors in neural network algorithms, etc.

It should also be noted that the use of AI for cybercrime has increased. For example, diplomatic accounts, fake identities, and voice fraud are used to imitate influential people, politicians, and businessmen. This technology can also be used to create "dead souls" at

enterprises to receive monetary rewards. AI algorithms can also influence the functioning of cryptocurrency exchanges by manipulating prices.

Thus, we can assume that there are risks from the use of AI. Today, it is difficult to predict what its impacts will be in 20-30 years and how they will be felt by ordinary users. Taking all this into account, the study focuses on the category of young people aged 18-23 who are potentially at risk of being exposed to AI in the future. Why was this group chosen? Today, young people are at the beginning of their future careers. Perhaps their choices now will affect their future, where there are potential threats from AI due to job loss, change of specialty, wrong decision-making, cyber threats, etc. Therefore, in this study, the authors tried to answer the scientific question of how young people perceive the risks of AI. Is it fear, hope, or indifference?

LITERATURE REVIEW

The driving force behind the development of the modern economy is digital transformation (Jarzębowski et al., 2024). Their impact is felt by countries regardless of the level of welfare (Kuzior et al., 2022). As a result, a digital gap is formed, which causes inequality in the competitiveness of countries and even violates national security (Kolupaieva & Tiesheva, 2023; Zámek & Zakharkina, 2024). That is why the development of technological innovations is a key aspect of long-term state and business strategies (Gondauri et al., 2024; Strielkowski et al., 2022). Digital transformation encompasses the adoption of technologies such as artificial intelligence, the Internet of Things, and big data, which are key to improving operational efficiency, reducing costs, and ensuring business sustainability in various industries (Tutak & Brodny, 2024; Sarker, 2022; Zhou, 2024). Bibliometric and network analysis of scientific publications revealed growing trends in research on AI and its use in various fields over the past few years (Bilan et al., 2022). At the same time, the greatest attention is paid to the legal, educational, economic and ethical aspects of AI (Prieto-Gutierrez et al., 2023).

There is a fairly close connection between the level of digitalization and the business ecosystem, as a result of which conditions favourable for technological growth are formed (Mursalov et al., 2023). They provide the technological basis for the development of AI, which in turn enhances the capabilities of additive technologies, allowing them to reduce costs, increase flexibility and maintain high-quality products (Melnyk et al., 2023). The possibilities of AI are promising, especially in accumulating new knowledge (Bencsik, 2021). It can predict economic crises, natural disasters, social conflicts, and bankruptcy of companies to counteract these threats quickly and effectively (Cherep et al., 2024; Letkovsky et al., 2023). AI is actively integrated into smart banking technologies: introduction of robot advisors (Piotrowski & Orzeszko, 2023), fraud recognition (Kozhushko, 2023), modelling of financial markets (Hrytsenko et al., 2024), cryptocurrency forecasting (Máté et al., 2024), management decision-making (Haddad, 2021), etc. The introduction of intelligent tutors, virtual assistants, automated grading systems, chatbots to support students, etc., makes AI attractive for improving online education (Louw et al., 2024; Skrynnyk et al., 2022). Its application in logistics enables information alignment and supply flexibility and also improves the digital awareness of users involved in supply chains (Aliane et al., 2023; Angammana & Jayawardena, 2022; Pereira & Shafique, 2024).

AI has not overlooked agriculture. For example, chatbots and chat rooms for management decision-making in farms are gaining practical significance (Ekanayake & Saputhanthri, 2020). Also, predictive models based on AI are more productive for big data compared to other methods (Kolková & Ključnikov, 2022). Combining robotic automated processes with AI increases labor productivity, lowers production costs, and improves business efficiency (Orlandić et al., 2024). Artificial intelligence can significantly increase the resilience of the capital chain of enterprises, especially in times of crisis (Li, 2023). Also, the practices of applying AI in realizing the benefits of implementing Green HRM are positive (Abid et al., 2024). AI can automate administrative tasks, provide fast data processing for decision-making, and detect and prevent corruption risks to promote transparency and accountability of public institutions (Androniceanu, 2023).

The intensive use of non-renewable resources and broken technological cycles lead to the destruction of the planet's ecosystems. However, the AI introduction in the transition to renewable resources and closed cycles can ensure the sustainability of economic activity and help the successful transformation of the traditional economy into a digital one (Melnyk et al., 2019). AI can significantly reduce risk in construction by predicting potential hazards and helping to avoid emergencies through real-time data analysis. At the same time, over-reliance on AI can lead to neglect of human judgment and unexpected failures if such systems give inaccurate predictions or become unavailable (Aneke & Oboho, 2024; Elkrghli & Almansour, 2024).

Federspiel et al. (2023) identify that there are three biggest threats from AI: the increased ability to control and manipulate people, the enhancement and dehumanization of lethal weapons, and the obsolescence of human labor. Hutter & Hutter (2021) believe that two states of AI impact can now be considered – the uncontrolled replacement of AI in decision-making processes, administrative processes and the main processes of production and service provision, as well as the dismissal of people through full automation. Both conditions can lead to unemployment, lower wages, increased social inequality, and changes in policies and standards in favor of pure materialism. Of course, humans want to retain the leading role and mediate between the biological and technological species (Tugui et al., 2022). But increasingly, AI affects what we do and how we interact with each other (Tai, 2020). The success of language models such as ChatGPT is so significant that in the process of communicating with it, one can get the impression that communication is happening with a real person. But Tredinnick & Laybats (2023) believe that this kind of experience shows more how to be a person than technological capabilities. Certainly, one can agree with the authors on this aspect, but AI can also produce other risks and threats.

Different economic, social and political conditions create the basis for a “brain drain” in many countries, forcing the government to implement AI to solve the problem of labor shortage (Iuga & Socol, 2024). On the one hand, it reduces costs for companies and solves the staffing problem, but on the other hand, it can worsen the situation when robots make wrong decisions due to errors in their algorithms. Cramarenco et al. (2023) note that AI affects the professional skills and well-being of workers, generating the risk of job loss through downskilling. Although, conditions for retraining and acquisition of new qualifications may be formed at the same time. The transition to remote work due to the pandemic has led to the introduction of advanced technologies for communication. Their use decreased the communication level

between team members and deteriorated the psychological climate in companies (Capolupo et al., 2022).

Nowadays, the global system for combating cyber threats is rather unstable, which is a consequence of the different levels of countries' digitization, and creates a favorable background for the growing use of AI for cybercrime (Kuzmenko et al., 2023). It is especially relevant in the fields of health care, telemedicine and insurance medicine (Dobrovolska et al., 2024; Pakhnenko & Pudło, 2023). In these areas, AI carries threats, first of all, related to ethics and data privacy, as well as increased diagnostic costs (Sheliemina, 2024). This kind of cyber threat can cause serious business disruptions as well (Havryliuk et al., 2023). The use of AI for botnet attacks has expanded the capabilities of criminals, ranging from infrastructure attacks to identity theft and financial fraud (Djenna et al., 2023). In addition, with the help of AI, cybercriminals can generate more convincing phishing attacks and tailor malware to the weaknesses of specific systems, which significantly increases security threats.

Thus, we can see the benefits of AI for various aspects of society's life, but we also cannot overlook and neglect the risks associated with it. That is why this study aims to find out whether young people perceive AI as a threat, or whether they believe that we will still be able to find a balance between machines and humans.

DATA

This study was based on data obtained from a survey conducted among students of higher education institutions. The sample consisted of 410 respondents, of which 38.54% were students from Ukraine, 34.63% from Poland, and 26.83% from Spain. The data is balanced, as the standard deviation is 4.87%, which is acceptable and allows for analysis both in general and with regard to individual groups limited by the country of respondents.

Students were asked three sets of questions. The first set was aimed at studying the respondents' personal experiences and attitudes toward artificial intelligence in everyday life. The questions covered such aspects as the professional orientation of the respondents, the frequency of using AI in everyday tasks, the level of trust in AI-based systems, personal attitude to the integration of AI into all spheres of life, assessment of the current level of AI development, and the respondents' opinions on whether the development of AI could pose a threat to humanity.

The second set of questions examined respondents' views on potential threats associated with the development of artificial intelligence and their attitudes toward the consequences of its introduction into the professional sphere and public life. The participants were asked to assess the most likely threats from AI, the professions that, in their opinion, are at the greatest risk of automation, their personal vision of the risk of losing their jobs due to the introduction of AI in their future profession, and their general attitude to whether automation will contribute to an increase in unemployment in the next 20-30 years. Particular attention was paid to the social implications, such as the possibility of deepening social inequality due to the development of AI, as well as professional skills that can help to preserve jobs in the face of rapid technological progress. The block also touched upon moral and ethical issues: whether AI is capable of making moral decisions on its own, whether respondents are willing to entrust robots with decision-making in critical situations, and whether they think AI can surpass human

intelligence and creativity in the future. The study also covered assumptions about the possibility of robots developing self-awareness, the risks of "machine revolt" similar to science fiction, and the threat of cybercrime.

The third set of questions was aimed at studying respondents' attitudes toward responsibility, regulation, and social support in connection with the development of artificial intelligence. In particular, respondents were asked who, in their opinion, should be responsible for possible negative consequences of AI use and whether they consider it necessary to control the development of AI at the legislative level. The role of governments in regulating the development and use of AI was raised, as well as the feasibility of retraining programs to prevent mass unemployment caused by automation. In addition, the views on the introduction of a universal basic income to support those who will lose their jobs due to automation and the assessment of humanity's readiness for the ethical challenges associated with the development and implementation of AI technologies were considered.

METHODOLOGY

The research methodology included three main stages and one preliminary stage, which involved bringing the data to the form required for further calculations and analysis.

The purpose of the first stage was to analyze the existence and strength of the relationship between two categorical variables, in our case, questions with answers, which allowed us to select the key ones for the formation of latent profiles. The Chi-squared test and Cramer's V coefficient were used for the analysis. The Chi-squared test helps to determine whether there is a statistically significant relationship between two variables and to answer the question of whether the survey results are random. The test was conducted by calculating the classic Chi-square value and p-value (Pearson, 1900). The Cramer's V coefficient helps determine the strength of the relationship between categorical variables. It was also calculated using the classical formula (Cramér, 1999). Also, Cronbach's alpha coefficient was used to assess the reliability (internal consistency) of the set of questions (Chen et al., 2024). It helps to determine the extent to which responses to different questions are consistent with each other, that is, whether they measure the same characteristic or construct. To apply this coefficient, the answers were re-indexed to a scale from 1 to 3. "3" was given to those answers that characterize full acceptance of AI and trust in it in all aspects of its manifestation; "2" to those that symbolize a cautious or balanced attitude towards AI and potential trust in it in some aspects; "1" to those that characterize distrust, rejection, and skepticism towards AI.

The second stage of the research methodology was devoted to Latent Class Analysis (LCA), which allows us to identify hidden (latent) groups based on similarities in respondents' answers. Such classes best explain their variability and help to understand what types of respondents exist in the sample and what common features or behavioral patterns unite them. LCA is effective for categorical data, which formed the basis of this study. It was carried out using the following algorithm:

1. First, One-Hot Encoding of input variables was performed, which converts each categorical variable X_i (question with answers) into binary vectors $(0, \dots, 1, \dots 0)$ of indicator variables $X_i^{(k)}$, where k corresponds to the number of categories for X_i, and a unit in the vector indicates a category correspondence.

2. Next, an optimal number of latent classes was determined using the Akaike information criterion (AIC) and Bayesian information criterion (BIC) (Akaike, 1974; Schwarz, 1978). As a result, the number of latent classes for which the AIC and BIC are minimal was chosen.

3. A latent class model was built. First, the probability that a respondent belonging to latent class c, has certain X answers was determined:

$$P(X|L=c) = \prod_{i=1}^{m} P(X_i|L=c), \quad (1)$$

where $P(X_i|L=c)$ is the probability of each answer X_i provided that the respondent belongs to the latent class c, where $c = \overline{1,C}$, and C is the total number of latent classes that need to be identified; L is a latent variable that indicates whether the i^{th} respondent belongs to one of the latent classes; X is a set of answers for the class c, where $X = (X_1, X_2, \dots, X_m)$.

Next, we determined the probability V of all observed data X for a certain number of latent classes C:

$$V = \prod_{j=1}^{n} \sum_{c=1}^{C} P(L=c) P(X_j|L=c), \quad (2)$$

where $P(L=c)$ is the probability of belonging to class c, and $P\left(X_j|L=c\right)$ is the probability of specific answers X_j for class c.

Next, the optimization was performed using an EM algorithm to estimate the parameters $P(L=c)$ та $P(X_i|L=c)$.

4. After setting up the LCA model, the probabilities of respondents' answers belonging to each class were determined:

$$P\left(L=c|X_j\right) = \frac{P(L=c)P(X_j|L=c)}{\sum_{k=1}^{C} P(L=k)P(X_j|L=k)}. \quad (3)$$

5. For each latent class, the average values of the answers of respondents belonging to it were calculated. Thus, a latent profile was formed for each class, which reflects which answers are typical for it.

At the third stage, scenario models were built based on the respondents' answers, which describe how events may develop depending on the respondents' views. Subsequently, they can be used to create forecasts, justify strategies, develop recommendations, and make management decisions. The scenario approach involved the following steps.

1. To create profiles of different scenarios, categorical answers were recoded into numerical values in the same way as for Cronbach's alpha coefficient calculation.

2. Five key areas of the scenario study were selected: attitudes toward AI, risks and threats associated with the development of AI, risks of unemployment and social inequality due to AI, regulation of AI, and expectations of AI capabilities in the future. For each key area, three baseline scenarios were formed, for which indicators were calculated using formulas (4)-(6):

$$A_i = \sum_{j=1}^{3} \gamma(x_{ij}, 3)\,;\; C_i = \sum_{j=1}^{3} \gamma(x_{ij}, 2)\,;\; D_i = \sum_{j=1}^{3} \gamma(x_{ij}, 1), \quad (4)\text{-}(6)$$

where A_i, C_i, D_i is the number of answers of the i^{th} respondent with a value of 3, which reflects acceptance and trust (A), 2 – caution (C), and 1 – skepticism and distrust (D); x_{ij} is each answer for the i^{th} respondent to the j^{th} question; $\gamma(a, b) = 1$, if $a = b$, and 0, if $a \neq b$.

3. For each i^{th} respondent a vector of indicators was built $v_i = (A_i, C_i, D_i)$, which reflects its attitude to AI in the form of scenario indicators.

4. Respondents were grouped by scenarios using the classic k-means clustering method. The results were stored as scenario clusters for each respondent.

5. For each respondent, the dominant scenario was determined, i.e. the scenario with the maximum value among the indicators A_i, C_i, D_i:

$$S_i^d = arg \max_{X \in \{A_i, C_i, D_i\}} X. \quad (7)$$

6. For each scenario, the total number of respondents was determined based on the dominant scenario identified for them.

The proposed methodology was implemented using the Python programming language.

EMPIRICAL RESULTS

At the first stage of the proposed methodology, the implementation of the Chi-square test allowed us to build 253 pairs of combinations of survey questions, of which 135 pairs were statistically significant, i.e., those with a $p - value \leq 0.05$. That is, respondents in most cases did not answer questions randomly and a certain relationship can be traced between them. The calculation of Kramer's coefficient allowed us to select those pairs of questions for which the relationship is the closest, although its value varies between weak and medium. Table 1 shows the final results for both calculations.

Table 1 includes those pairs of questions for which Cramer's V exceeds 0.2, which indicates a weak or closer to average relationship. Although we did not get high enough values of Cramer's V to indicate a strong relationship between pairs of questions, the result is acceptable in a data set with only categorical values. Let's analyze the pairs with the closest relationship, which are highlighted in grey.

The results show that the frequency of AI use is characterized by cross-country differences, i.e. students from different countries have different access to and awareness of technologies (Q1-Q2, Table 1). The respondents also showed different opinions on the legislative control of AI, which is influenced by the specifics of technology regulation in different countries (Q1-Q13, Table 1). The correlation between questions Q2 and Q3 (Table 1) shows that respondents who use AI more often in their daily lives show more trust in it than those who do not use such software. Pairing Q4 and Q6 (Table 1) indicates that those who believe that AI can be a threat to human development are also concerned about its impact on the labor market in the future. This category of respondents is also concerned about the growth of social inequality that technology may cause (Q4-Q7, Table 1) and is more supportive of the need for legislative control (Q4-Q13, Table 1).

Table 1. Results of the Chi-squared test and Cramer's V [Source: calculated by the authors]

Var 1	Var 2	Chi-squared	P-value	Cramer's V	Var 1	Var 2	Chi-squared	P-value	Cramer's V
Q1*/**	Q2	67.3852	0.0000	0.2645	Q7	Q13	60.1861	0.0000	0.2040
Q1	Q16	56.8154	0.0000	0.2439	Q7	Q14	69.6161	0.0000	0.2220
Q1	Q4	43.0885	0.0000	0.2126	Q8	Q10	61.6686	0.0000	0.2069
Q1	Q13	57.6858	0.0000	0.2510	Q8	Q11	105.3618	0.0000	0.2799
Q2	Q3	113.3108	0.0000	0.2827	Q9	Q11	61.2926	0.0000	0.2061
Q3	Q17	73.3709	0.0000	0.2287	Q9	Q19	38.8926	0.0000	0.2002
Q4	Q6	104.4343	0.0000	0.2785	Q10	Q11	77.7532	0.0000	0.2364
Q4	Q7	95.5618	0.0000	0.2652	Q11	Q19	51.6585	0.0000	0.2359
Q4	Q12	74.9488	0.0000	0.2262	Q12	Q14	72.4855	0.0000	0.2217
Q4	Q13	87.5270	0.0000	0.2526	Q12	Q15	88.9311	0.0000	0.2500
Q4	Q14	81.8145	0.0000	0.2433	Q13	Q14	216.6449	0.0000	0.4109
Q4	Q15	62.1806	0.0000	0.2079	Q13	Q15	63.3105	0.0000	0.2101
Q4	Q18	69.1126	0.0000	0.2210	Q13	Q18	75.5729	0.0000	0.2326
Q5	Q6	73.6447	0.0000	0.2238	Q14	Q15	81.4872	0.0000	0.2427
Q6	Q7	65.4824	0.0000	0.2142	Q15	Q18	60.9923	0.0000	0.2056
Q7	Q12	71.4638	0.0000	0.2198	X	X	X	X	X

Note. * The grey color corresponds to question pairs with a Cramer's V of approximately 0.3, equivalent to an average connection. **Q1 – In which country do you study? Q2 – How often do you use AI in your everyday life? Q3 – Do you trust AI systems used in everyday life? Q4 – Do you think that the development of AI poses a threat to humanity? Q5 – How do you assess the risk of job loss for yourself due to the AI implementation in your future profession? Q6 – Do you think automation and AI will increase unemployment in the next 20-30 years? Q7 – Are you concerned about the possibility that the development of AI could lead to a deepening of social inequality? Q8 – Do you think AI will be able to make moral decisions on its own? Q9 – Do you think AI can surpass human intelligence in the next 20-30 years or later? Q10 – In your opinion, will AI be able to surpass human creativity in the future? Q11 – Do you think robots could become self-aware in the future? Q12 – Do you believe there is a risk associated with using AI in cyber fraud, such as manipulating images to impersonate individuals? Q13 – Is it necessary to control the development of AI at the legislative level? Q14 – How would you rate the role of governments in regulating the development and use of AI? Q15 – Do you think governments should implement reskilling programs to prevent mass unemployment due to automation? Q16 – How do you evaluate the level of development of modern AI? Q17 – How do you feel about integrating AI into all areas of human life? Q18 – Do you think humanity is sufficiently prepared for the ethical challenges associated with the development of AI? Q19 – Do you think there is a risk of machine rebellion as described in movies or books?

Students who believe in the ability of AI to make independent moral decisions that affect human health and life are more likely to admit that AI can achieve self-awareness and pose a threat in the future (Q8-Q11, Table 1). In other words, respondents do not dismiss the risk that AI decision-making processes may lead to AI becoming equal to human consciousness. The high correlation between pairs Q13-Q14 (Table 1) indicates that respondents who consider the introduction of legislative control of AI to be an important task also have a more positive assessment of the role of governments in regulating this issue. This indicates that respondents tend to rely on the state to resolve issues related to the development of computer technologies. The connection between questions Q12-Q15 (Table 1) may indicate a broader understanding of the risks of AI, both in terms of its use for criminal purposes and economic consequences.

Respondents who are concerned about AI risks are also more likely to support active government intervention to mitigate the negative consequences.

Also, it was determined that Cronbach's reliability coefficient is equal to 0.672 for the set of questions selected due to applying the Chi-squared test and calculating the Kramer coefficient. According to generally accepted recommendations, values between 0.6 and 0.7 are considered satisfactory, confirming our instrument's internal consistency. Although we tried to optimize the scale, in particular, revising the questions, changing the wording and clarifying the instructions for the respondents did not lead to a significant increase in the coefficient. This may be due to the high complexity of the measured construct, which includes various aspects that are difficult to accurately measure with a single instrument. Since in our context, the value of 0.672 is acceptable, we consider it sufficient for the analysis.

In the second stage, "latent profiles" of respondents with similar sets of answers were formed. Their number was justified using the calculated Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) (Figure 1). It turned out that the lowest BIC value is achieved for three latent classes, and the lowest AIC value is achieved for five. It was decided to form three "latent profiles" based on the results of the BIS, as such models provide better interpretability, long-term reliability, cost-effectiveness, and sustainability.

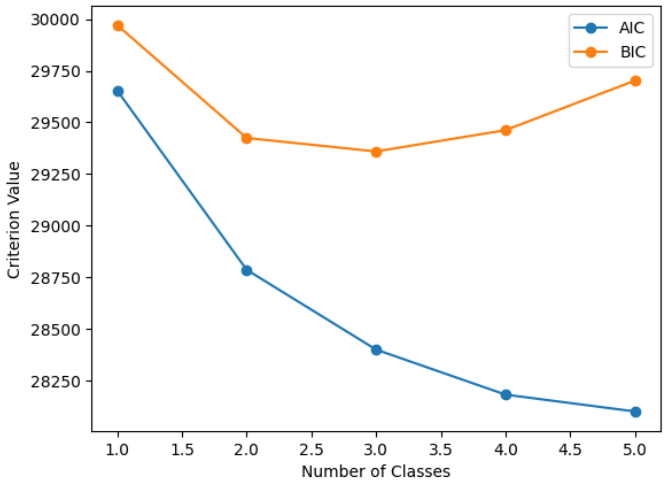


Figure 1. Determining the number of latent classes using criteria AIC and BIC.
[Source: calculated by the authors]

As a result, the following distribution of respondents by the three latent profiles was obtained (Figure 2).

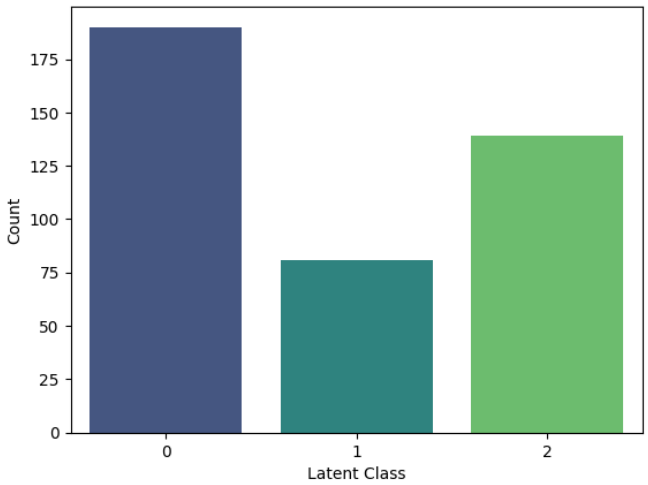


Figure 2. Distribution of respondents by latent classes. [Source: calculated by the authors]

Class 0 includes 46.3415% of respondents, class 2 - 33.9024%, and class 1 - 19.7561%. The result of the distribution is relatively standard. Its standard deviation is 10.8609%. This indicates that the answers are distributed significantly around the mean value with significant variations. The distribution shows skewness with a higher concentration in the 0^{th} class, indicating a large group of respondents who are likely to have similar answers. At the same time, the standard deviation indicates a significant variation in the respondents' answers, which means that although the majority is in the same class, there are still significant fluctuations between classes, indicating a polarization of views.

The latent profile of class 0 (Figure 3) demonstrates answers with a probability of approximately 0.5 or higher. It can be identified as a balanced and pragmatic view of AI. This group was formed mainly by students from Ukraine and Poland. The probability of falling into this profile is close to the average, i.e., 0.4474 and 0.4053, respectively. In general, we can say that respondents of this class, on the one hand, recognize the potential and capabilities of AI, and on the other hand, are wary of possible negative consequences and social threats that may arise from its implementation and development.

Figure 3. Probabilistic characterization of the 0th latent profile. [Source: calculated by the authors]

The majority of respondents demonstrated a high level of cautious attitude toward AI in everyday life (0.9105), which may indicate a high level of awareness of the risks of its use. This category also understands that although the development of technology is quite high (0.5632), it can have unpredictable or even dangerous consequences (0.6211). On the other hand, they believe that the level of impact of AI development on humanity is exaggerated (0.8053). Respondents showed a significant level of concern about cyber threats from AI (0.5053), but they do not consider it a major threat that could lead to deepening social inequality (0.5789). Moreover, they are not convinced of the possibility of a "machine uprising," which indicates a pragmatic approach to the future of AI (0.5526). Respondents believe that AI will probably not be able to surpass human creativity or intelligence because they are unique (0.5737), but can be useful in certain areas. The answers to the questions about whether AI can surpass human intelligence (0.5947), achieve self-awareness (0.6316), or make moral decisions (0.4842) show uncertainty and caution in the respondents' views. They tend to believe that it is possible but unlikely or difficult to predict.

Regarding risks in the professional sphere, only 49.4737% estimate their job loss due to AI and automation at the average level, which indicates a slight concern, although they are aware of possible changes in the future. A sufficient number of respondents believe that an increase in unemployment in the future due to AI is possible but temporary (0.6684). They support the idea of retraining and adapting the workforce to new conditions but believe that this should be an initiative of the employees themselves (0.5632). Respondents noted that we are partially prepared for the ethical challenges associated with AI, so there is a need for relevant discussions and legislative regulation (0.7895). At the same time, government control over the development and implementation of AI technologies should still be balanced (0.7211). Also, there should be no excessive restrictions at the legislative level so as not to hinder the scientific and technological process (0.7000).

This latent profile characterizes a group of people who understand the benefits and potential of AI, but they demonstrate a pragmatic view of the likelihood of threats from AI self-awareness, decision-making, or insurgency. Respondents in this class are aware of potential risks from cyber threats, social inequality, or ethical behavior but do not overestimate them.

They support reasonable government control over the development of technology and adaptation to changes in the labor market. All of this indicates that respondents want AI to become a useful tool for humanity, but subject to certain ethical standards and legal restrictions.

Figure 4 shows the latent profile of the 1st class, which reflects the most significant answers to the question (probability approximately equal to or greater than 0.5). Its respondents are characterized by a rather skeptical view of AI risks with elements of caution and trust. This group is the smallest of all, with students from Ukraine forming the majority (0.6420).

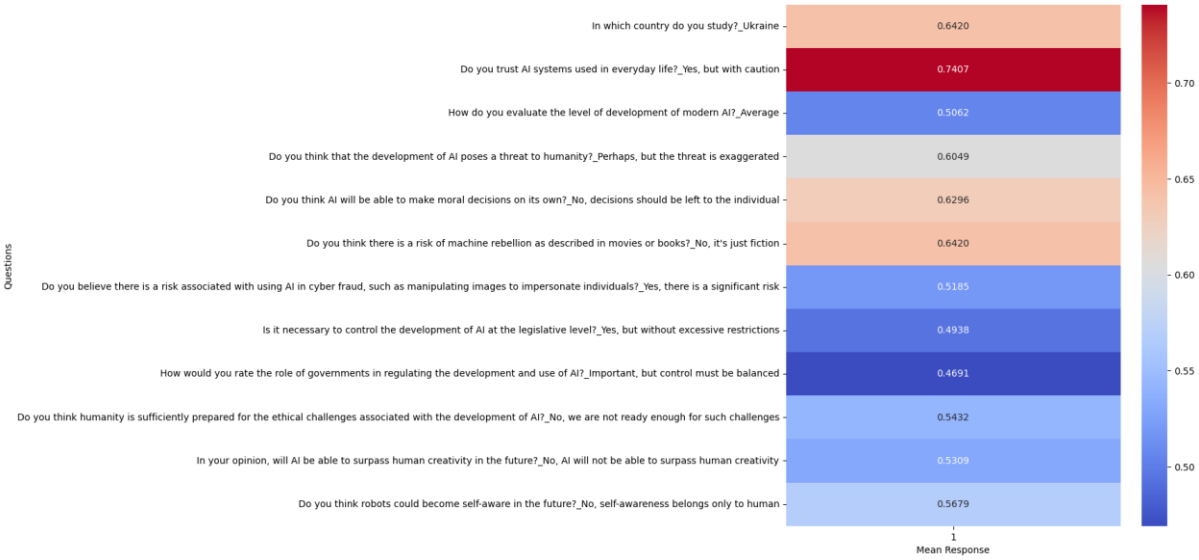


Figure 4. Probabilistic characterization of the 1st latent profile. [Source: calculated by the authors]

Most respondents are cautious about using AI in everyday life (0.7407). This indicates that they are aware of the potential risks and the need to control the use of AI for ordinary users. This behavior is also confirmed by the answer to the question about the possibility of moral decision-making by AI. Students chose the option that only humans should reserve this right (0.6296). The respondents of this group assess the level of modern AI development as average (0.5062). This result may indicate that respondents perceive technological development as incapable of affecting their lives, so it cannot be dangerous enough for humanity. Accordingly, 60.4938% believe that the threats posed by AI to humanity are exaggerated. That is, respondents are cautious about AI and do not see serious risks to society.

The respondents of this latent class demonstrated a skeptical attitude toward the ideas of "machine revolt" (0.6420) and robots gaining self-awareness (0.5679). They consider such scenarios to be fantastic and unlikely, which reflects a lack of confidence in the possibility of a real machine revolt or AI reaching the level of human self-awareness. Respondents' skepticism is also manifested in the fact that AI will not be able to surpass human creativity (0.5309). They are convinced that AI cannot compete with humans in creative aspects due to limitations in algorithms.

Nevertheless, respondents demonstrated a certain level of concern about the potential of AI to commit cybercrime (51.8519% consider this risk to be significant). This is most likely due to the current level of cyber threats and the awareness of the growing danger of such risks in the future. Respondents in this group support balanced state regulation of the development

and use of AI technologies (0.4691), although opinions are not unambiguous, which indicates a difference in views on this issue. They also believe that it is necessary to form legal mechanisms to control the activities of AI developers, although they also demonstrate their balance, as they choose the option of control without excessive restrictions (0.4938). 54.3210% doubt that humanity is sufficiently prepared for the ethical challenges posed by AI. This may indicate that they are aware of the need to develop and implement ethical standards for the use of AI.

In general, this latent profile demonstrates a skeptical attitude toward AI threats, albeit with elements of personal caution. Respondents believe that the risks of AI's impact on humanity are overestimated, as the level of its development is not sufficient for this. Also, AI will not acquire self-awareness and creativity, and make decisions instead of humans, and its use will not lead to a robot uprising. It should be noted that the respondents in this group do not perceive professional risks in the future. They consider them low for themselves (41.9753%). In this regard, they are more inclined to believe that AI will create new jobs (37.0370%) or that it will lead to unemployment for a short period of time (32.0988%). The respondents' views on legal and governmental control and regulation are fairly balanced.

The results of the Class 2 latent profile are shown in Figure 5, which includes responses with a probability of approximately 0.50 or higher. Respondents in this class are characterized by a cautious attitude toward AI and a high level of risk anxiety. With a probability of 53.9568%, this behavior is typical of Spanish students and with a probability of 30.9353% - of Polish students (not included in Figure 5).

In everyday life, respondents of this class trust AI with caution (0.7986). They also warn about the negative consequences of integrating AI into various spheres of life (0.6691). This means that they recognize the high potential of the technology and rate the development of AI at a high level (0.5755), but feel the need to introduce stricter controls and restrictions to prevent its abuse. Respondents believe that the development of AI can be a real threat to humanity (0.5108). Although this value is not very high, which indicates some uncertainty, there are a sufficient number of people who consider this risk to be significant.

Figure 5. Probabilistic characterization of the 2nd latent profile. [Source: calculated by the authors]

This group includes respondents who are moderately confident that AI will deepen social inequality (0.4532) and those who do not consider AI to be a major threat to social inequality compared to other aspects (0.4532). At the same time, the probabilities of forming these points of view are the same. This suggests that respondents recognize potential future threats of AI to their social well-being, although this is likely to depend on a number of reasons other than AI.

More worrisome is the issue of automation and its impact on the labor market. Respondents believe that this could become a serious problem in the coming decades, particularly for low-skilled workers (0.5971). At the same time, they assess the risk of losing their jobs as a medium, which shows that they are aware of the real challenges, but without strong anxiety (0.5180). Students agree that in the future retraining of workers is necessary to prevent mass unemployment due to automation (0.6547), which indicates the importance of developing IT specialties at all levels of the educational process.

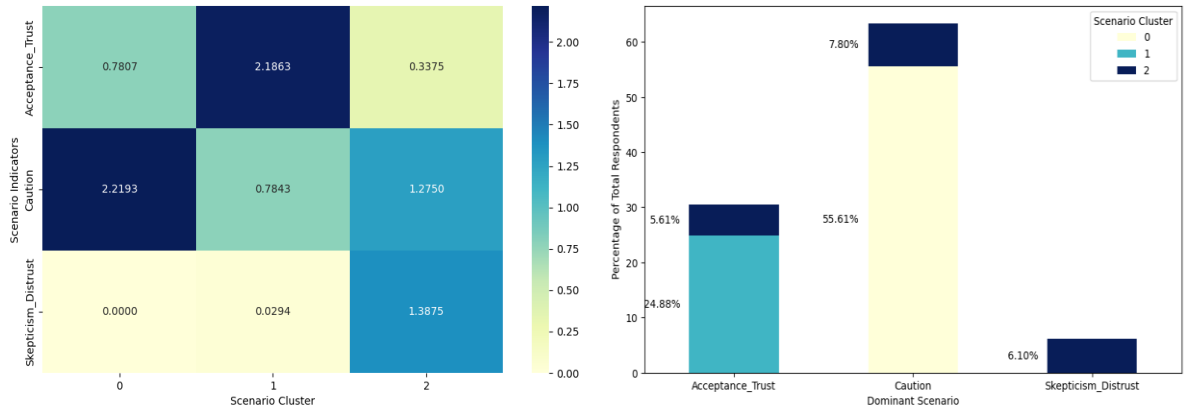
Respondents believe it is likely that AI may surpass human intelligence in the future, although this is not a convincing majority (0.5252). This indicates a sufficient cluster of people who fear that AI can replace humans in various spheres of life. Students also give a high rating to the risk of AI being used for cybercrime (e.g., image manipulation for deception) (0.7986), indicating that they recognize the existence of significant threats to personal security and privacy.

Respondents in this latent group strongly support the idea of strict control over AI development at the legislative level (0.7986), which only confirms previous findings about their concern about potential negative consequences and cautious attitude towards AI in everyday life. They prefer strong government control over the development and use of AI (0.5467), which indicates the need for clear laws and standards. It should be noted that the opinion of this group may have been influenced by the cultural characteristics of their country (Spain), which is characterized by a high level of the rule of law. The respondents are quite categorical on the issue that humanity is not ready for the ethical challenges associated with the development of AI (0.4892), although this group is not the overwhelming majority. This fact further emphasizes the need for further discussions and initiatives by governments to address ethical issues.

The second latent profile characterizes a group of people with a cautious attitude to AI development and a high level of concern about professional, social, and ethical risks. They rate them quite highly and, accordingly, consider it necessary to introduce strict control at the legislative level, regulate these issues by the state, and create conditions for retraining employees in the context of total automation.

Based on the results of the survey, the third stage involved a scenario approach that allowed for an in-depth analysis in five key areas. As a result, scenarios for the first area were formed, which demonstrate respondents' attitudes toward AI and their readiness to implement it in various spheres of life (Figure 6a). It was found that the "Cautious Attitude" scenario prevails today, i.e., the majority of respondents (63.4146%, Figure 6b) admit the possibility of using AI in certain areas, but subject to restrictions that will not allow crossing the line and replacing humans in solving key tasks. The scenario "Acceptance of AI and high trust" is accepted by 30.4878% (Figure 6b) of respondents. That is, they have a positive attitude toward AI integration and a high level of trust in its use in everyday life. Perhaps this is the asset that will promote new technologies in the future. A total of 6.0976% (Figure 6b) of participants formed

the “Skepticism and distrust” scenario, who see real threats from AI and therefore do not use the relevant programs at all or use them occasionally.



a) b)

Figure 6. “Attitudes toward AI” scenarios: a) Scenario Profiles Heatmap; b) Distribution of Respondents by Dominant Scenarios and Scenario Clusters. [Source: calculated by the authors]

According to each of the scenarios, the distribution of respondents by the use of AI applications was determined (Figure 7). Thus, it can be seen that respondents in the “AI Acceptance and High Trust” scenario use such applications more than participants in other scenarios. At the same time, a small percentage fell into the category of those who do not use any AI applications, which indicates either the insincerity of some respondents or that they trust such programs completely, although they do not use them themselves, or use programs that are not on the given list. The respondents in the “Skepticism and distrust” scenario fully met expectations and still use such programs the least. It should be noted that the leadership belongs to programs such as ChatGPT or AI-based recommendation systems, such as Netflix, You Tube, Spotify.

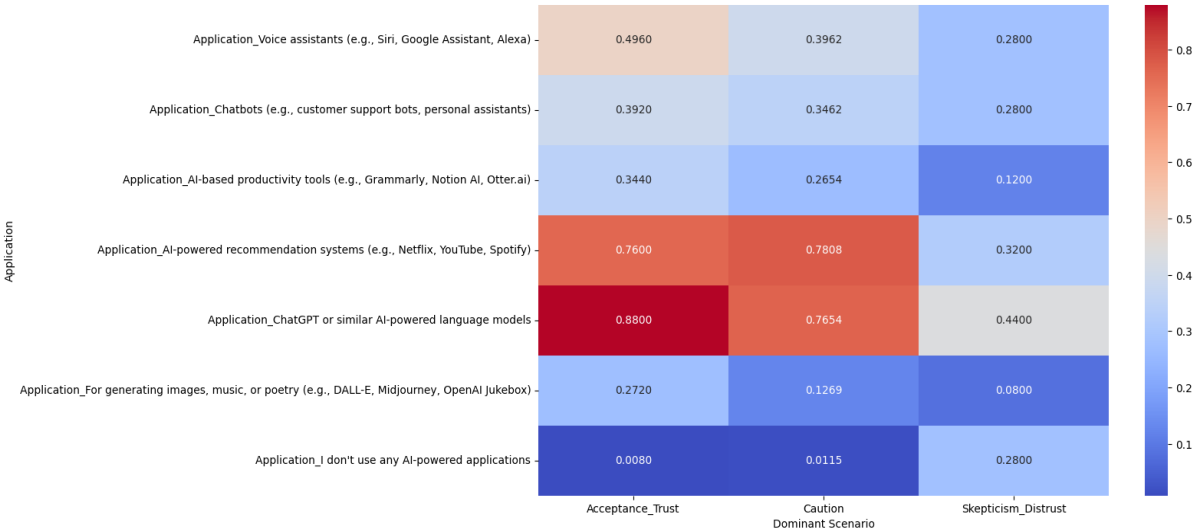


Figure 7. Distribution of respondents by the use of AI applications depending on the dominant scenario. [Source: calculated by the authors]

The next group of scenarios is aimed at identifying the risks and threats associated with the development of AI (Figure 8a).

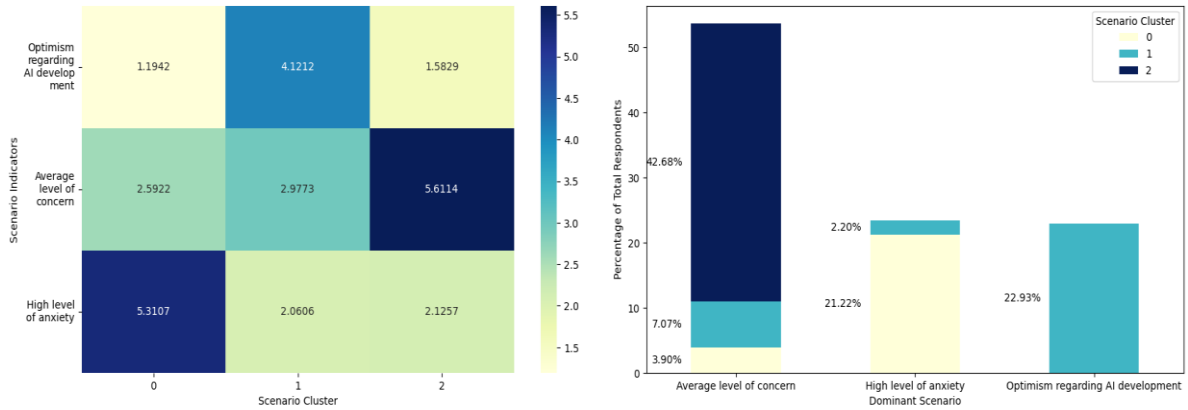


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Figure 8. "Risks and Threats Related to AI Development" scenarios: a) Scenario Profiles Heatmap; b) Distribution of Respondents by Dominant Scenarios and Scenario Clusters.
[Source: calculated by the authors]

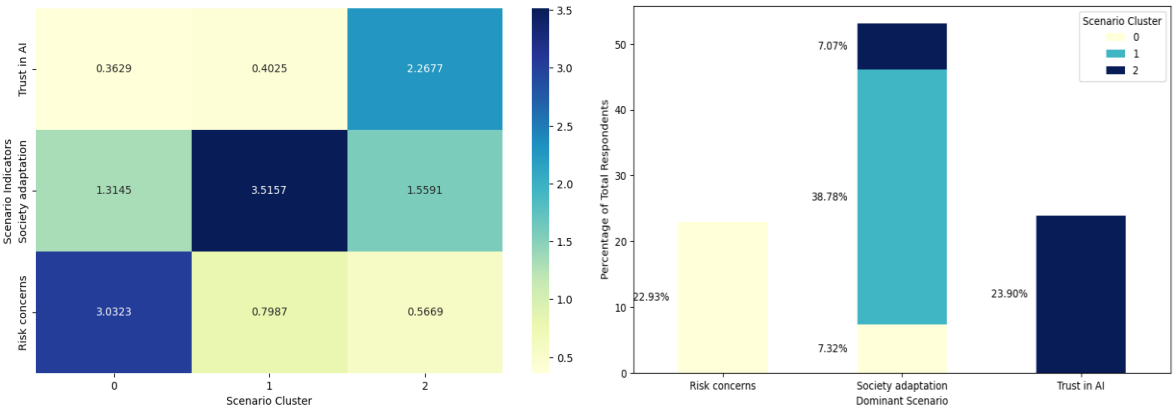
It was found that about half of the respondents (53.6585%, Figure 8b) adhere to the "Average level of concern" scenario, i.e., they are concerned about some aspects of AI application and believe that threats should be controlled, but there is no need to stop AI development. The scenarios "High level of anxiety" and "Optimism regarding AI development" have approximately the same number of supporters - 23.4146% and 22.9268%, respectively (Figure 8b). That is, some respondents consider AI a potential threat to society and are fatalistic in this aspect. They expect negative consequences for the labor market, deepening social inequality, increasing cyber threats, etc. On the other hand, some respondents see the risks as insignificant or minimal and emphasize the opportunities of AI that will only bring significant benefits to society.

Each of the identified scenarios of perceived risks and threats is characterized by the following distribution of respondents (Figure 9).

Figure 9. Average risk perception by AI threats across dominant scenarios.
[Source: calculated by the authors]

Figure 9 shows that respondents in the "High level of anxiety" scenario have the highest level of anxiety about all types of threats. They are especially worried about losing their jobs due to automation, criminal acts involving AI, and the devaluation of creative professions. Optimistic students are less likely to believe that AI poses a threat to humanity, but they are also concerned about the growth of cybercrime and potential risks in the labor market. Although this category of respondents is more favorable to AI, they are concerned about the development of digital cretinism, which may result from the excessive use of AI in the process of solving everyday tasks. Students in the "Average level of concern" scenario demonstrate a balanced attitude toward risk perception, although they also identify threats of job loss and cybercrime as critical to humanity.

The scenarios of Figure 10a describe the perception of the risks of unemployment and social inequality due to AI. In this area, most respondents believe that society will still be able to adapt to the changes initiated by AI, including through the adoption of appropriate retraining programs by the state and the introduction of a universal basic income to support workers who have lost their jobs due to automation (53.1707%, Figure 10b). The "Trust in AI" and "Risk concerns" scenarios are characterized by approximately the same number of respondents - 23.9024% and 22.9268%, respectively (Figure 10b). That is, some respondents believe that the introduction of AI will not lead to significant problems in the labor market and that its use will improve the quality and productivity of labor and will not affect social inequality. Students whose answers correspond to the "Risk concerns" scenario tend to believe that automation will significantly increase unemployment, especially in some professions, including creative ones. They are also most concerned about the possible growth of social inequality and the concentration of technology in the hands of a small group.



a) b)

Figure 10. "Risks of unemployment and social inequality due to AI" scenarios: a) Scenario Profiles Heatmap; b) Distribution of Respondents by Dominant Scenarios and Scenario Clusters.
[Source: calculated by the authors]

According to each scenario, the distribution of perceived risks to professions due to AI was determined (Figure 11). Thus, according to respondents, office workers, programmers, and creative industry workers were the most vulnerable. These professions are considered the most risky in each of the three scenarios. Healthcare workers and teachers will be less affected by the introduction of AI.

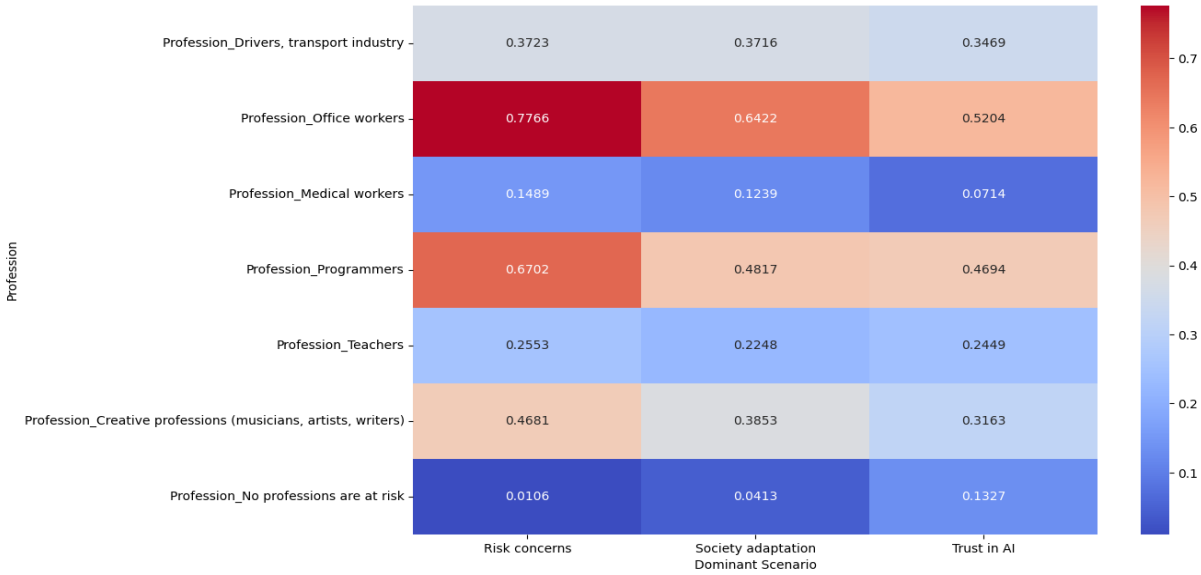


Figure 11. Average risk perception by profession across dominant scenarios.
[Source: calculated by the authors]

What professional skills will be most important for keeping a job in the AI era? Respondents who answered the "Trust in AI" scenario prioritized the ability to adapt and learn new skills, critical thinking and problem solving, creative and innovative thinking, and interpersonal communication (Figure 12). Respondents in the "Risk concerns" scenario also

favored these four skills, although they still consider creative and innovative thinking to be the most important (Figure 12). The social adaptation scenario demonstrates the greatest balance, which is manifested in approximately the same frequency for all analyzed types of skills needed in the future (Figure 12).

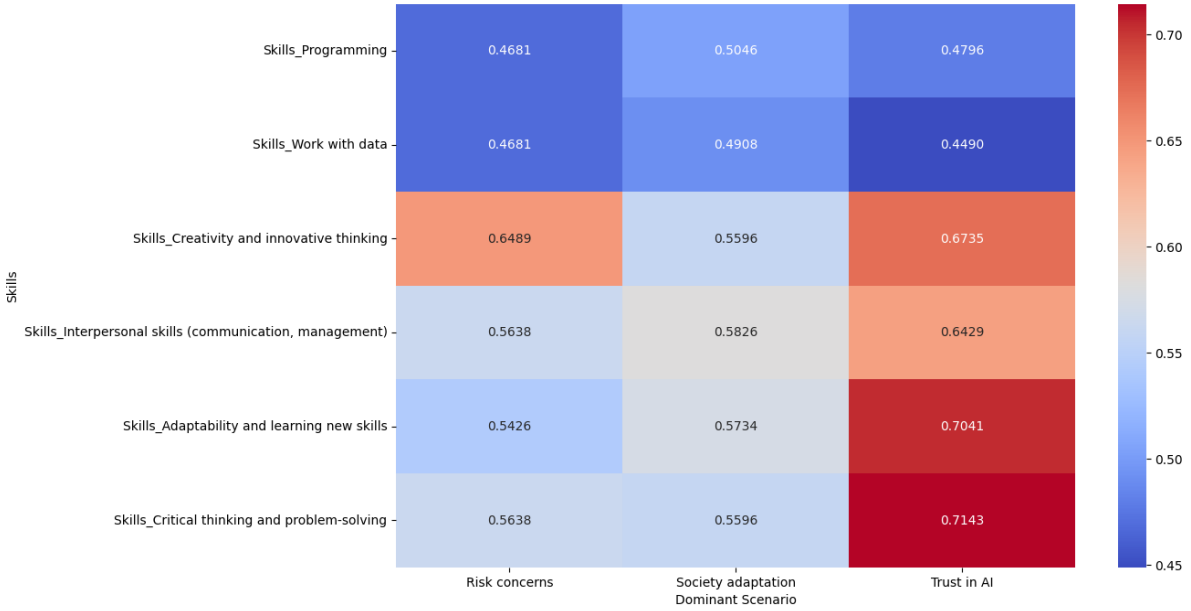


Figure 12. Professional skills preferences across dominant scenarios. [Source: calculated by the authors]

Figure 13a shows a heat map of scenarios related to AI regulation. 60.7317% of respondents support the “Flexible regulation” scenario (Figure 13b). That is, they are not in favor of strict measures in general, but they favor a gradual approach to restrictions and adaptation of legislation to new conditions. They also believe that the state should be involved in control, but the responsibility should be placed more on AI developers and corporations that implement it (Figure 14). 27.8049% believe that the introduction of AI requires stricter legislative measures and governmental actions (Figure 13b). At the same time, they are the most likely to believe that there should be increased responsibility on the part of AI developers and corporations (Figure 14). The “Rejection of regulation” scenario has only 11.4634% of supporters (Figure 13b). Respondents support minimal government intervention and believe that AI development should be regulated exclusively by the innovation environment. They also place more responsibility on users of AI-based applications (Figure 14).

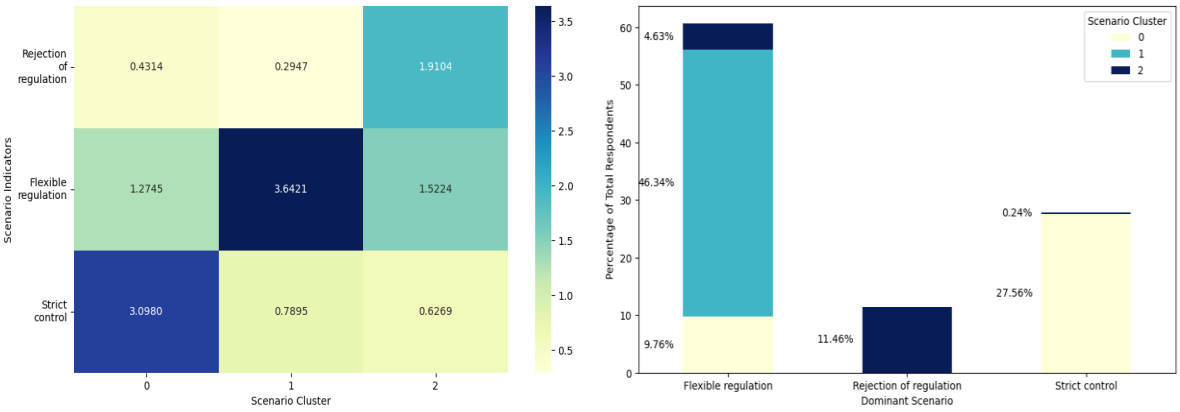


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Figure 13. "AI regulation" scenarios: a) Scenario Profiles Heatmap; b) Distribution of Respondents by Dominant Scenarios and Scenario Clusters. [Source: calculated by the authors]

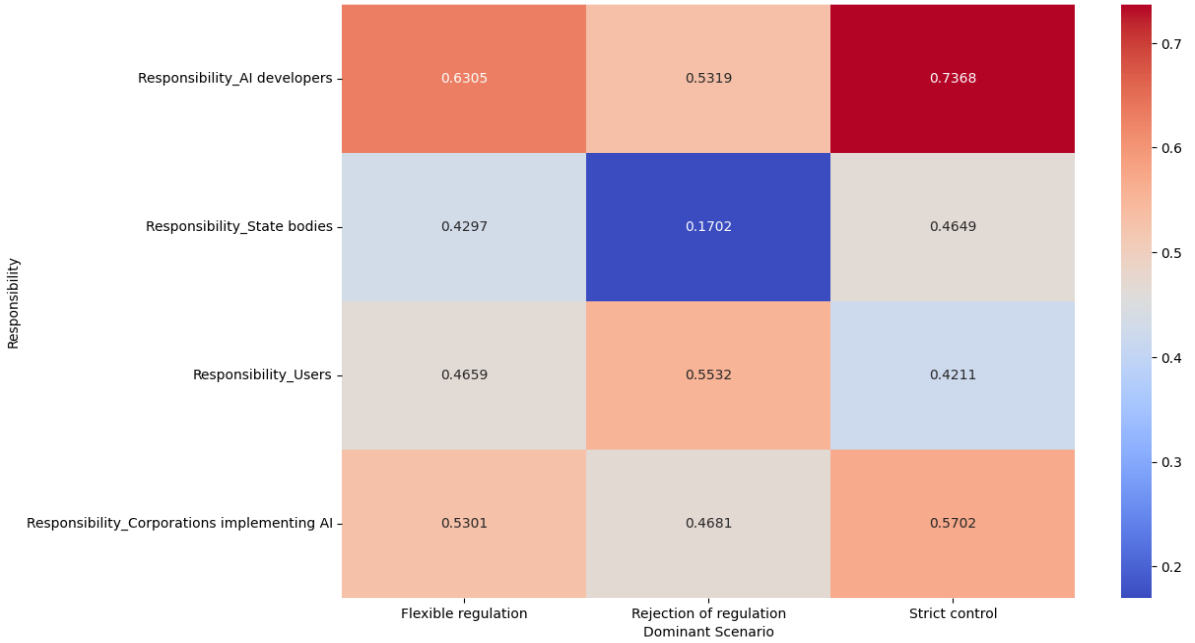

Figure 14. Distribution of respondents' answers regarding responsibility for AI based on the dominant scenario. [Source: calculated by the authors]

The last group of scenarios focuses on expectations about the development and capabilities of AI in the future (Figure 15a). Supporters of the "AI will surpass humans" scenario were the smallest among all (18.5365%, Figure 15b). They believe that AI will be able to surpass human intelligence and even become self-aware in the future, will be able to make moral decisions, and will succeed in creative professions. Almost the same number of respondents support the scenario "Limited capabilities of AI" (40.9756%, Figure 15b) and "AI will not surpass humans" (40.4878%, Figure 15b). That is, some respondents believe that AI will not be able to surpass human capabilities in the near future and will remain a tool of choice. The other part is not so categorical and is of the opinion that AI will be able to enhance human capabilities in the process of performing everyday tasks. Still, also in certain areas, it will be able to replace humans, albeit with certain limitations.

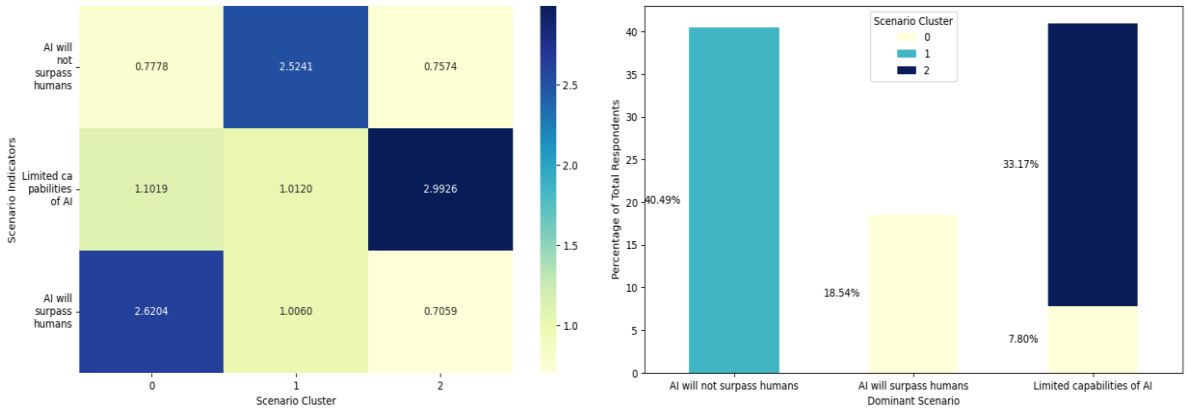

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Figure 15. "Expectations for AI capabilities in the future" scenarios: a) Scenario Profiles Heatmap; b) Distribution of Respondents by Dominant Scenarios and Scenario Clusters.
[Source: calculated by the authors]

DISCUSSION

Nowadays, digital transformations are a continuous process that cannot be stopped because they are irrevocably changing our world. However, their speed can slow down under the influence of various human needs and circumstances. Thus, the COVID-19 pandemic has significantly affected the development of the digital transformation of small and medium-sized enterprises in the manufacturing sector, but Bednářová et al. (2023) note their slowdown in some spheres. Kuzior et al. (2023) believe that today the need for a reliable cyber security system prevails over the active development and implementation of technologies, which may indicate a gradual slowing down of this process over time. Despite this, AI has already filled various niches and continues to actively enter everyday life. This study focused on the potential risks that may arise because of robotics and the use of AI. Like the majority of respondents in the conducted research, we should accept these risks as an integral part of intelligent automation. But still, it is necessary to increase attention to measures to regulate IT issues and avoid complications from this kind of threat. The opinions of many experts correlate with the conclusions of this article.

Dotsenko et al. (2024) believe that a comprehensive approach is needed, which should cover the development of security infrastructure, ethical and legal regulation. The obsolescence of the legal framework can become a restraining factor not only for the development of digital transformations but also for a secure environment for users (Maatallah, 2024). Therefore, the improvement of legislative initiatives in the field of AI should be among the top tasks for the governments of countries. Fülöp et al. (2023) believe that state regulatory bodies should be more actively involved in ethical legislation in the field of AI. The transfer of technologies is accompanied by significant risks, which require the development of an algorithm for their management in a scientific and educational environment to overcome barriers and stimulate the internationalization of technological exchange (Novikova et al., 2022). Informational transparency and openness of AI development companies in the context of digitalization can play a significant role in reducing AI risks (Lyeonov et al., 2023). Business managers must be

ready for modern technological challenges, which require a new style of management and leadership (Benchea & Ilie, 2023). Also, the synergy between knowledge management and AI can ensure the correctness of management decisions to achieve the company's strategic goals (Kuzior et al., 2024).

The organizations' adaptation to digital technologies is crucial, which will contribute to the improvement of personnel management processes, attracting talent and increasing the efficiency of companies' activities (Prokopenko et al., 2023). Bian & Wang (2024) confirmed the existence of a relationship between employee motivation, their moral norms and moral cognition and the use of AI in decision-making processes. Therefore, companies should pay attention to the development of an ethics code to regulate these issues. Businesses that actively use AI need new approaches related to compensation, corporate culture, training and identity, which can reduce risks from AI in the future (Nuñez & Bolognesi, 2024). Measures are needed to overcome the inequality between "worker-worker" and "worker-robot", which will help reduce social tension over time (Ostapenko et al., 2024). In addition, user self-efficiency is a vital aspect to consider when using AI-based programs (Höller et al., 2023). It should not be forgotten that public awareness of AI risks can prevent many dangers for users (Wojciechowski & Korjonen-Kuusipuro, 2023; Moravec et al., 2024). Therefore, governments should create conditions for investing funds in educational activities to train specialists in such areas as cyber security, data protection, AI, etc. (Koibichuk & Dotsenko, 2023).

Thus, a comprehensive approach, which will include measures of legal regulation, ethical norms, improvement of educational programs, creation of new management approaches, and transparency in the activities of AI development companies, are the considered steps that must be taken now to prevent risks and threats that may arise from AI.

CONCLUSIONS

The rapid development of technology has influenced the introduction of AI in various spheres of life. In addition to positive effects, this has led to the emergence of risks associated with its use. The current state of affairs makes us wonder what will happen in the future: will robots be able to replace humans? Can they become conscious? Will automation lead to a deepening of social inequality? The authors tried to find answers to these and other questions among young people and assess their perception of AI risks.

The first stage of the methodology, based on the survey data of students from three countries, allowed us to assess the non-randomness of the answers to the questions, which was confirmed by the Chi-squared test. The assessment of the strength of the connection between pairs of questions revealed that the respondents' affiliation with the respective country, the frequency of their use of AI in everyday life, their level of trust in technology, their perception of threats from AI in general, its impact on unemployment, social inequality in the future, robots' self-awareness, cyber threats, and the need for legal regulation and government control are important.

Determining latent profiles at the second stage allowed us to identify three groups of respondents whose formation was influenced by their geographical location. Respondents from Poland and Ukraine are most likely to be members of the zero profile, which is more characterized by pragmatism in perceiving threats from AI's self-awareness, decision-making,

or insurgency. They are aware of certain types of AI risks but do not overestimate them. Students in this group support flexible government control that does not limit the development of AI. The first, least numerous, latent profile was formed by skeptics, which includes mostly Ukrainian students. They demonstrated a rather skeptical attitude toward threats from AI. Respondents in this class do not believe that AI's capabilities will allow it to surpass humans in various fields, as they consider the development of technology to be insufficient for this. Despite all this, they are also cautious about the use of AI and concerned about cybersecurity. The probability of falling into the second profile for Spanish students is quite high. This group is characterized by a cautious attitude to AI development, a high level of concern about professional, social, and ethical risks, and a commitment to strict control to regulate these issues.

The third stage of the research allowed us to create scenarios for five key issues. It was found that respondents are cautious about the use of AI and are ready for its implementation in various spheres of life. Regarding various types of risks and threats posed by AI, respondents have a balanced strategy: they are concerned about some types of risks, support flexible control, and believe that there is no need to stop the development of AI. Students are inclined to believe that AI will not be a major threat to social inequality in the future and that the labor market will be able to adapt to the changes initiated by AI. Still, respondents hope for protection from the state through the adoption of appropriate retraining programs and the introduction of a universal basic income to support workers laid off due to AI. The dominant scenario regarding AI regulation was support for flexible state regulation measures that reduce risks for users and do not reduce the level of innovation in technology. As for the future development of AI and risks, two scenarios prevail. Students are of the opinion that AI will never replace humans, will not gain consciousness, and will not lead to catastrophic events such as robot uprisings, etc. The other group of respondents gives AI a certain chance to surpass human abilities, but this can happen in certain areas and with certain restrictions. In general, the scenarios suggest that young people mostly have certain expectations for AI in the future, although they are still cautious about it. There are also groups of skeptics and those who are afraid of the risks posed by AI, but this is most likely due to a lack of awareness of these issues, limited use of such programs, and the cultural and legal peculiarities of the countries to which the respondents belonged.

This research can play a significant role in the development of future strategies and policies by government agencies, international associations, AI development companies, universities, and NGOs. The fact that there is a certain level of distrust and cautiousness about AI among young people suggests that they feel some anxiety about the future. Therefore, this opinion should be taken into account to prevent situations that will lead to the complete replacement of humans by artificial intelligence and robots in various spheres of life or even to a machine uprising. By understanding how students perceive AI and understand the potential risks associated with it, universities can adapt their curricula by adding relevant courses on AI ethics, risk management, and legal frameworks. The results of the study can be used by the government to improve state policies and strategies to develop appropriate restrictions on the use of AI and its introduction into society. Taking into account the opinion of young people, AI development companies can improve policies for the responsible use of AI by software users with a focus on introducing more active security measures, limiting learning algorithms, increasing the price of paid content, etc. International and non-governmental organizations can

use the results of the study to form youth initiatives and organize public discussions on AI risks. In addition to the above, this study has the potential to be expanded to include respondents of different age groups and countries, which will allow for further consideration of the opinions of a larger number of people.

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SURFING, SCROLLING AND STRESSING: TECHNOSTRESS IN BROWSING DIGITAL CONTENT FEEDS ON SMARTPHONES FROM THE GRATIFICATIONS AND DIMENSIONS OF USE PERSPECTIVE

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Abstract: *In this study, we investigate how the nature of activities users perform to interact with information delivered via smartphones (i.e., dimensions of smartphone use), along with gratifications sought and obtained, contribute to technostress in the context of digital content feeds. By applying qualitative research methods and analyzing data gathered through 30 semi-structured interviews, we identify five dimensions of smartphone use: instant, repeated, continuous, personalized, and versatile. Introducing the concept of smartphone use loop, we reveal the dynamic relationships between these dimensions, gratifications, and technostress, illustrating how different dimensions of use and underlying gratifications can lead to diverse technostress experiences (e.g., depending on whether the gratifications sought are obtained). Furthermore, we identify previously unexplored technostressors and strains, such as gratification mismatch and worsened boredom tolerance. By integrating uses and gratifications theory with technostress research, this study offers a novel framework for understanding the dual nature of smartphone use.*

Keywords: *technostress, uses and gratifications theory, dimension of use, smartphone, qualitative research*

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INTRODUCTION

While smartphones have undeniably contributed to positive change in our society by facilitating access to information technology (IT) anywhere and anytime, such has not come without drawbacks. Prior studies have characterized mobile technology as a double-edged sword (Dén-Nagy, 2014; Qi, 2019), with smartphone use at bedtime described as "sleeping with the frenemy" (Hughes & Burke, 2018, p. 236). Additionally, research has linked various forms of IT, including smartphones (e.g., Lee, Chang, Lin & Chen, 2014; Malik, Dhir, Kaur & Johri, 2021) and social media (e.g., Maier, Laumer, Eckhardt & Weitzel, 2015; Maier, Laumer, Weinert & Weitzel, 2015; Salo, Pirkkalainen & Koskelainen, 2019), to technostress, that is, stress caused by IT use (Tarafdar, Cooper & Stich, 2019). It has been shown that technostress can harm users' well-being (Fischer & Riedl, 2017; Salo et al., 2019), underscoring the importance of studying the phenomenon further.

In the present study, we focus on technostress associated with digital content feeds viewed on smartphones. This focus is motivated by the widespread adoption and ubiquity of smartphones, used by billions globally, and the significant influence digital content feeds have on the information consumed through these devices. These types of feeds have even been associated with a type of flow state in which the users "are so engrossed in an activity that little else seems to matter to them and they will often continue the activity despite its negative consequences" (Roberts & David, 2023, p. 80), making them an interesting context for investigating technostress. Moreover, Gerlach and Cenfetelli (2020) propose that factors like the need to stay up-to-date motivate constant device checking, highlighting the necessity for further research to examine "the costs and benefits" of these behaviors (Gerlach & Cenfetelli, 2020, p. 1722). Therefore, understanding why users engage with digital content feeds on smartphones despite experiencing technostress is a critical area of inquiry.

We define digital content feeds as constantly and dynamically updating information streams from various services, applications, and websites. Notable examples of such feeds are present on social media (e.g., Instagram), instant messaging services (e.g., WhatsApp), and news sites and applications, which all have been associated with technostress (Ardèvol-Abreu, Delponti, Bonache & Rodríguez-Wangüemert, 2023; Salo, Pirkkalainen, Chua & Koskelainen, 2022; Whelan, Islam & Brooks, 2020). Consequently, when we mention smartphone use in our study, we refer to use centered around digital content feeds. Examining the technostress caused by browsing digital content feeds on smartphones and understanding why individuals continue this behavior despite its contribution to technostress is critical from multiple perspectives. It raises important questions: Who finds themselves in technostress-inducing situations, why do they engage in these behaviors, and how do such situations arise? Understanding this is essential for designing services that prioritize users' well-being and for educating users about the diverse and often problematic consequences of their smartphone-related behaviors.

There is a growing body of knowledge regarding technostress within the personal and leisure contexts. For instance, overdependence (Salo et al., 2019), fear of missing out (FOMO) (Malik et al., 2021; Dhir, Yossatorn, Kaur & Chen, 2019), overload (Cao & Sun, 2018; Fu, Li, Liu, Pirkkalainen & alo, 2020), invasion (Maier, Laumer, Weinert at al., 2015; Salo et al., 2022), and social comparison (Fox & Moreland, 2015; Salo et al., 2019) have all been identified as *technostressors* (i.e., stress-creating stimuli caused by different situations and events) in

personal IT use. Moreover, prior studies have revealed how IT use for personal purposes may lead to *strains/outcomes* (i.e., psychological, physical, and behavioral reactions to technostressors) such as exhaustion (Cao, Masood, Luqman & Ali, 2018; Cheikh-Ammar, 2020), concentration and sleep problems (Salo et al., 2019), reduced happiness (Brooks, 2015), and use discontinuation (Maier, Laumer, Weinert at al., 2015). Thus, the emergence of technostress through various technostressors and resulting strains/outcomes is well-documented in the literature. However, this process is shaped by numerous factors, including individual characteristics (Lee et al., 2014; Hsiao, 2017), the features of the IT itself (Ayyagari, Grover & Purvis, 2011; Salo et al., 2019; Tugtekin, Barut Tugtekin, Kurt & Demir, 2020), and patterns of usage (Maier, Laumer, Weinert et al., 2015). These influences underscore the dynamic and complex nature of technostress.

Despite existing research, there is limited understanding regarding the positive gratifications users seek (gratifications sought; tightly linked to needs or motives) and obtain (gratifications obtained; satisfying the needs by receiving gratifications) (Quan-Haase & Young, 2010; Palmgreen & Rayburn, 1979) through smartphone use and the impact of technostress as an associated negative outcome. Furthermore, previous studies have not addressed the nature and characteristics of smartphone use in relation to technostress. The uses and gratifications theory posits that individuals actively select media based on the gratifications they seek and obtain (Bae, 2018). Applying this perspective to the study of technostress offers a valuable lens for understanding the active role users play in engaging in behaviors that contribute to technostress. Understanding *why* and *how* individuals use smartphones in situations they experience technostress is crucial for providing answers and solutions for reducing the adverse consequences, such as negative well-being outcomes.

Our exploration of different dimensions of smartphone use (which reflect how individuals use smartphones; what is characteristic of the use) and gratifications (which reflect why individuals use smartphones; what individuals seek and obtain from the use) sheds light on the complex dynamic of the positive and negative facets of smartphone use in the personal context. The concept "dimension of smartphone use", which we define as *the nature of activities performed by users to interact with information delivered via smartphones*, helps us discern the associations between gratifications sought and obtained, and technostress. Building on these insights, we address two key research gaps: (1) the lack of exploration into what users seek and obtain from smartphone use in the context of technostress, and (2) the absence of explicit discussion on the dimensions of smartphone use and their relationship to technostress. Here, we answer the following research question: *How do the dimensions of smartphone use, the gratifications sought and obtained, and technostress interplay in the personal use context focusing on digital content feeds?* We address this question by applying a qualitative research approach and analyzing data from in-depth interviews with 30 smartphone users.

We contribute to the research in three ways. First, we adopt a dual perspective on gratifications for technostress research following Palmgreen and Rayburn (1979), which involves both the gratifications sought and obtained. We illuminate the complex interplay between users' underlying motives, cognitions, behavior, and their actual experiences associated with technostress. By integrating insights from uses and gratifications theory and technostress research, we provide a comprehensive exploration of how personal engagement with digital content feeds on smartphones can contribute to technostress. In doing so, we expand the discourse on balancing IT use in personal contexts (Steelman & Soror, 2017).

Second, we treat uses and gratifications as separate constructs and introduce the concept of smartphone use loop, which illustrates the dynamic interplay between gratifications sought, dimensions of smartphone use, and gratifications obtained in relation to technostress. We propose an explicit categorization for the dimensions of smartphone use comprising five dimensions: instant, repeated, continuous, personalized, and versatile. This classification extends beyond previous research grounded in uses and gratifications theory, offering a more nuanced understanding of smartphone use and its relationship with technostress. Third, we identify unexplored technostressors (techno-procrastination, online information bubbles, gratification mismatch) and strains/outcomes (worsened boredom tolerance) arising from the interplay of dimensions of smartphone use and gratifications sought and obtained.

The remainder of the paper is structured as follows. In the next section, we introduce the theoretical background of our study. Subsequently, we discuss the applied research methods and present our results. We then discuss how our findings extend the understanding of the research topic as well as how practitioners could benefit from the results. We also address the limitations of the study and offer directions for future research.

THEORETICAL BACKGROUND

Technostress

Stress occurs when individuals encounter stressors, which are stress-creating stimuli caused by different situations and events that result in strains and other outcomes, which are psychological, physical, and behavioral reactions to stressors (Cooper, Dewe & O'Driscoll, 2001; Lazarus & Folkman, 1984). Overall, stress can be viewed as a dynamic transactional process, where stress represents an interaction between the individual and the environment that the individual appraises as potentially harmful (Lazarus, 1966; Lazarus & Folkman, 1984). While stress is often associated with highly uncomfortable situations and events, even smaller daily stressors—especially when encountered perpetually—can prove detrimental (Charles, Piazza, Mogle, Sliwinski & Almeida, 2013). In the present study, we focus on stress caused by IT use, known as technostress (Tarafdar et al., 2019). Although stress is typically viewed negatively (distress), we emphasize that it can also have positive manifestations (eustress) (Cavanaugh, Boswell, Roehling & Boudreau, 2000). For instance, the holistic technostress model incorporates sub-processes for both techno-distress and techno-eustress, explaining their emergence through distinct types of technostressors: hindrance-stressors and challenge-stressors, respectively (Califf, Sarker & Sarker, 2020). Moreover, Tarafdar, Stich, Maier, and Laumer (2024) further outline four techno-eustress creators: techno-mastery, techno-autonomy, techno-relatedness, and techno-enrichment.

The term technostress was coined in the 1980s in organizational context (Brod, 1982), and the phenomenon has established itself as a central concept for understanding "the dark side of IT" (Tarafdar, Tu, Ragu-Nathan & Ragu-Nathan, 2011). Technostress emergence can be explained through use practices, IT environmental conditions, and the above-mentioned technostressors and strains/outcomes (Ayyagari et al., 2011; Nastjuk, Trang, Grummeck-Braamt, Adam & Tarafdar, 2024; Salo et al., 2022; Tarafdar et al., 2019). Fundamentally, technostress arises when individuals interact with IT and perceive certain IT environmental

conditions (i.e., IT characteristics such as ubiquity) as demands or threats (technostressors) that exceed their abilities to cope, resulting in different kinds of (negative) outcomes or strains (Tarafdar et al., 2019). Especially technostressors and strains have received scrutiny in previous research. In the organizational context, well-established technostressors include techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty (Fischer & Riedl, 2017; Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008; Tarafdar, Tu, Ragu-Nathan & Ragu-Nathan, 2007). Previous studies have demonstrated that such stressors may negatively impact the benefits organizations can derive from IT due to reduced productivity and efficiency (Hung, Chen & Lin, 2015; Pirkkalainen, Salo, Tarafdar & Makkonen, 2019; Tarafdar et al., 2007). Moreover, such experiences of technostress can provoke deviant behaviors among employees, which may result in significant costs for organizations (Chiu, Tan, Hsu, & Cheng, 2023). Despite the above-mentioned five technostressors having roots in organizational research, studies concerning personal IT use have adapted them as well (Tarafdar, Maier, Laumer & Weitzel, 2020).

As IT use differs in organizational and personal/leisure contexts due to the voluntariness of use, studies have identified technostressors especially characteristic in personal IT use context. There does not exist a similar, widely accepted inventory of technostressors for the personal contexts as for the organizational. However, Nastjuk et al. (2024) proposed a list of six such technostressors based on prior research (Maier, Laumer, Weinert at al., 2015; Tarafdar et al., 2020): pattern, disclosure, complexity, invasion, uncertainty, and social overload. Other prevalent technostressors identified for personal contexts include overdependence (Salo et al., 2019), FOMO (Dhir et al., 2018; Malik et al., 2021), and social comparison (Fox & Moreland, 2015; Salo et al., 2019). Studies also have associated phenomena such as compulsive use (Dhir et al., 2018), excessive use (Luqman, Cao, Ali & Masood, 2017), and addiction (Tarafdar et al., 2020) with technostress in the context. The strains/outcomes identified in the personal technostress research include exhaustion (Cao et al., 2018; Cheikh-Ammar, 2020), concentration, social relation, and sleep problems (Salo et al., 2019), and reduced happiness (Brooks, 2015). In addition to technostressors and strains/outcomes, elements such as IT (e.g., push notification and self-disclose features) (Salo et al., 2019) and usage characteristics (extent of social media usage, number of social media friends) (Maier, Laumer, Eckhardt et al., 2015), and use practices (Salo et al., 2022) have been discussed in the personal use context of technostress. Especially social media as a specific use context has received attention in previous personal IT use technostress research (e.g., Maier, Laumer, Eckhardt et al., 2015; Salo et al., 2019). In such a context, it has been shown that, for instance, not obtaining the gratifications sought may contribute to fatigue from using social media, which could be stressful (Ravindran, Yeow Kuan & Hoe Lian, 2014). However, previous studies have yet to explore various gratifications sought and obtained and their interplay with technostress in detail, which we do in the context of personal smartphone use in the present study.

Focusing on personal smartphone use, especially compulsive (Hsiao, Shu & Huang, 2017; Lee et al., 2014) and excessive use (Cao et al., 2018; Luqman, Masood, Shahzad, Shahbaz & Feng, 2021) have been associated with technostress. The prevailing approach has been that technostressors (such as overload) lead to strains (such as fatigue) or other outcomes (such as discontinued use) (e.g., Sun & Lee, 2022). Some studies have also examined the impact of personality traits (e.g., Hsiao, 2017; Lee et al., 2014) or IT characteristics (Tugtekin et al., 2020) on the process. Beyond these examples, however, studies on smartphones remain limited

in addressing other factors that influence the emergence of technostress. Given that (techno)stress is a dynamic and transactional process, it is essential to investigate individuals' behavior and underlying cognitions to better understand how technostress arises. To this end, we expand the current knowledge by examining the "hows" and "whys" of personal smartphone use in relation to the dynamics of technostress. This approach broadens the focus beyond technostressors and strains/outcomes to encompass individuals' interactions with IT environments. In the following section, we discuss why and how individuals use IT, establishing the uses and gratifications theory as our theoretical lens to understand user cognitions and behaviors associated with technostress.

Uses and Gratifications

The uses and gratifications theory, originating from communication research during the 1940s, explains why and how people consume media (Ruggiero, 2000). The theory posits that users have needs they wish to satisfy and, therefore, make active media-related choices to receive gratifications (Katz, Blumler & Gurevitch, 1974). More recently, the theory has been applied to explain the use of modern media and IT (Sundar & Limperos, 2013), including the Internet (LaRose & Eastin, 2004; Stafford, Stafford & Schkade, 2004), social media (Bae, 2018; Ku, Chen & Zhang, 2013; Yang, Xu, Land, Yang & Chesney, 2024), and smartphones (Gentina & Rowe, 2020; Joo & Sang, 2013). The choice of uses and gratifications theory as a lens for observing the phenomena of interest in this study was driven by one of the strengths of the theory, its flexibility, since it does not rely on fixed variables (Lin, 1996; Mäntymäki & Riemer, 2014). Moreover, existing research has demonstrated the applicability of uses and gratifications theory in exploring the nuances of technostress, particularly from the perspective of user cognitions underlying IT use and their relationship to experienced technostress (e.g., Ardèvol-Abreu et al., 2023; Baabdullah et al., 2022). These studies provide valuable insights into the underlying factors of the phenomenon. Interestingly, despite experiencing stress, individuals may persist in using stress-inducing technologies in their personal lives (Cheikh-Ammar, 2020), potentially driven by the gratifications they derive from such use (Chaouali, 2016). Consequently, we find that this theoretical framework aligns well with our research objectives.

The issue of why media or IT is used can be discussed by dividing the gratifications into gratifications sought and gratifications obtained. More specifically, gratifications sought can be seen as the driving forces (closely related to needs or motives) behind media use, while gratifications obtained can be seen as the desired outcomes of the use (Palmgreen & Rayburn, 1979; Quan-Haase & Young, 2010). If the gratifications sought and obtained are aligned, individuals are likely to continuously engage with the source of those gratifications (Krasnova, Veltri, Eling & Buxmann, 2017; Rokito, Choi, Taylor & Bazarova, 2019). By contrast, if a discrepancy exists between the gratifications sought and obtained, people may be unsatisfied, reducing their use (Bae, 2018). Even though some studies have shown the importance of both the gratifications sought and obtained, such an approach has received less attention (Bae, 2018; Palmgreen & Rayburn, 1979).

In addition to gratifications sought and obtained, gratifications can be categorized according to what people specifically seek and obtain from media and IT use. An example of such categorization is a three-way categorization of hedonic (related to enjoyment or pleasure), utilitarian (related to usefulness), and social (related to social interaction) gratifications (e.g.,

Li, Liu, Xu & Heikkilä, 2015; Mäntymäki & Riemer, 2014). Focusing on smartphones, prior studies have shown how their use is associated with, for instance, entertainment (hedonic) (Ha, Kim, Libaque-Saenz, Chang & Park, 2015), communication (social) (Gentina & Rowe, 2020), and information-seeking (utilitarian) (Joo & Sang, 2013) gratifications.

In previous uses and gratifications studies, use has been discussed with different terms and emphases in various contexts. Traditionally, use has been characterized as either ritualistic or instrumental (Rubin, 1984). Furthermore, drawing on gratifications, different types of use, such as information-seeking and entertainment use (van Deursen & van Dijk, 2014), have been established. As we discuss dimensions of use in the present study, we note that the term has been used in previous research. The term has been used to describe specific types of uses, namely the information dimension (e.g., to learn about events), friendship dimension (e.g., to keep in touch with friends), and connection dimension (e.g., for dating purposes) (Bonds-Raacke & Raacke, 2010). In the context of smartphones, process and social dimensions of smartphone use have been identified (Elhai, Levine, Dvorak & Hall, 2017). Beyond uses and gratifications research, the term "dimensions of use" has been applied to describe various aspects of Internet use, including the amount (how much users engage), variety (how many different activities users undertake), and types (the kinds of activities users participate in) (Blank & Groselj, 2014). Similar approaches have employed the term "usage characteristics" to capture factors such as relationship length and usage experience (Kim, Wong, Chang & Park, 2016), as well as the extent of social media use and the number of social media connections (Maier, Laumer, Eckhardt et al., 2015).

We address use and gratifications as separate yet interconnected concepts and, therefore, consider that the types of uses (van Deursen & van Dijk, 2014) and dimensions of use that focus on specific types of uses (Bonds-Raacke & Raacke, 2010) are not adequate typologies for the study. We approach use from a different level of abstraction, focusing on what characterizes the use, examining its underlying nature. Approaching use this way, previous studies have mentioned, for example, constant use (Duke & Montag, 2017; Gerlach & Cenfetelli, 2020; Salo et al., 2022), although there does not appear to exist a holistic categorization for such dimensions of smartphone use. Also, although the uses and gratifications theory has been previously applied in studies discussing the negative consequences of IT use (Baabdullah et al, 2022; Chaouali, 2016; Gentina & Rowe, 2020; Sun, Liu & Zhang, 2020), exploring both the gratifications sought and obtained in relation to technostress is scarce. Furthermore, prior studies have not explained the nature of IT use in relation to gratifications and technostress. Our concept of dimensions of smartphone use gives insight into the interplay of gratifications sought and obtained and their relation to technostress. By drawing on the established technostress and uses and gratifications literature, we identify different dimensions of smartphone use and link them to gratifications and technostress with our empirical study as follows.

RESEARCH METHODS

Data Collection

We adopted a qualitative research approach in this study, given its suitability for examining how individuals engage with their technological environments (Myers, 1997). To collect data,

the first author interviewed (semi-structured interviews) 30 individuals (11 men and 19 women). Ten interviews (nine face-to-face and one remote) were done in 2019, while 20 remote interviews were conducted in 2021. The interview durations ranged from 34 to 77 minutes (average: 54 minutes). To identify interviewees, we applied a purposeful sampling method by seeking "information-rich cases for in-depth study" (Patton, 2002, p. 230), with the help of snowballing. In essence, the goal was to identify interviewees who were active smartphone users and had experienced technostress. This was accomplished by explicitly outlining these criteria in our research call. While the initial goal was to recruit young adults, who are traditionally active users of smartphones, we ultimately prioritized identifying individuals who used smartphones and had experienced technostress, irrespective of things such as their smartphone use patterns or age. By doing this, we were able to recruit a sample that represented "a variety of voices" (Myers & Newman, 2007, p. 22). Such an approach was deemed important for our goal of providing deep insights into the phenomena of interest, rather than providing results that could be generalized.

The interviewees were between 22 and 41 years old (average: 27 years), and they were all native Finnish speakers living in Finland. All interviewees were students, employed, or a combination of the two. The professions of the employed interviewees were diverse (e.g., pharmacist, human resources specialist, firefighter, masseuse, and early childhood educator). Regarding their smartphone use, the most used applications were Instagram (a social media platform) and WhatsApp (an instant messaging service). In addition, interviewees mentioned using other social media, including Facebook, Snapchat, TikTok, and Reddit. Moreover, many interviewees reported using their smartphones to access various news sources, including tabloid news, local media, and news related to specific topics like the economy. The time the interviewees spent using a smartphone ranged from under an hour up to nine hours a day, with the average time being around five hours. The individuals in our sample exhibited both similarities and differences in their psychosocial development, history of IT use, and current smartphone-related behaviors, allowing us to gather data that was both rich and consistent.

The interview method offers both strengths, such as the potential to gather rich, detailed data, and weaknesses, including the artificial nature of the interview setting (Myers & Newman, 2007). This artificiality may have led participants to provide socially desirable responses rather than fully authentic accounts of their experiences. Such responses might also stem from a lack of trust between the interviewer and the interviewee (Myers & Newman, 2007). To address these challenges, the interviewer adopted a neutral and natural demeanor, allowing the interaction to unfold organically and giving participants space to articulate their experiences and emotions in their own words (Myers & Newman, 2007). Techniques such as mirroring were employed to facilitate deeper discussions and encourage participants to elaborate on their experiences (Myers & Newman, 2007). Additionally, the interviewer demonstrated familiarity with the specialized jargon related to the IT context under study—specifically, various types of digital content feeds used on smartphones—helping to minimize social dissonance and foster a more open dialogue.

All the interviews focused on two main themes, namely why and how the interviewees used their smartphones (gratifications sought and obtained; dimensions of use) and what kinds of stressful or negative consequences they had experienced as a result (technostressors and the ensuing outcomes). Thus, the interview framework was partly based on existing research. In terms of their smartphone use, the interviewees were asked, for example, what digital content

feeds they browsed on their smartphones, why and how they browsed the content, and what they thought they received from the use. Regarding the stressful or negative consequences of smartphone use, the interviewees were asked, for example, what kinds of stressful or negative experiences they had had while using smartphones, what types of use they engaged in during experiencing such, and what consequences such experiences had caused for them. Despite us following a framework during our interviews, we were "prepared to explore interesting lines of research, and look for surprises", as is the nature of semi-structured interviews (Myers & Newman, 2007, p. 17). After conducting 30 deep and narrative-rich interviews, we determined that sufficient saturation had been reached as our preliminary analysis of the data indicated that the emergence of new insights from additional interviews regarding our research problem had significantly diminished at this stage. This meant that similar patterns of technostress experiences and their underlying conditions were highly repetitive in the participants stories. Figure 1 describes the different steps conducted during our data collection and analysis phases.

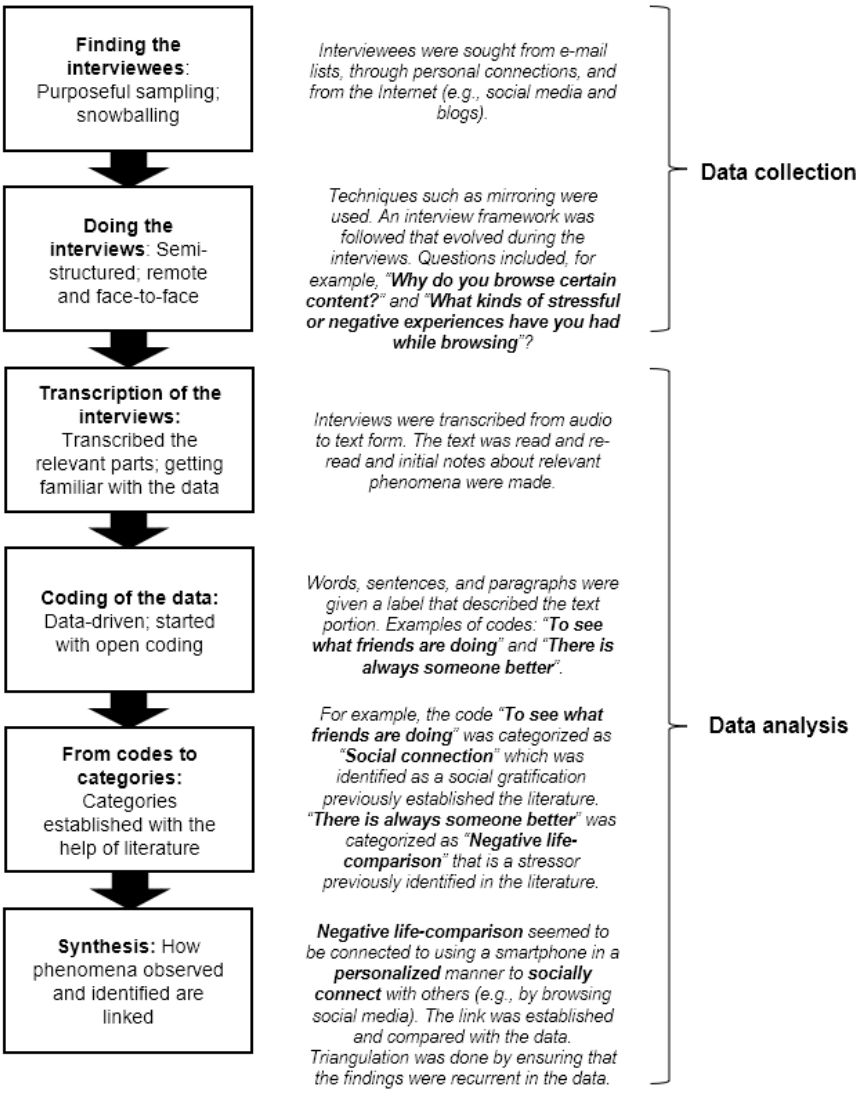

Figure 1. Data Collection and Data Analysis.

Data Analysis

As a first step, the interviews were transcribed, during which the first author made initial notes concerning the data. Subsequently, the first author read and re-read the transcriptions and made further notes about relevant observations. After the first author had become sufficiently familiar with the data, they began to code it following established guidelines (Lune & Berg, 2017; Saldaña, 2013). Although the first author conducted the primary analysis, they collaborated with the co-authors to discuss aspects such as the codes, emerging categories, and their relationships. The data was analyzed iteratively, beginning with open coding using NVivo software. During this process, we could dive deep into the data and become more familiar with them (Saldaña, 2013). This phase "allows researchers to identify and even extract themes, topics or issues in a systematic manner" (Lune & Berg, 2017, p. 125). Reflecting on the research question, all relevant pieces of data were labeled. Subsequently, the codes were initially assigned to three groups: 1) why the interviewees used their smartphones, 2) what kinds of stressful or negative events and situations they had encountered due to the use, and 3) what kinds of (negative) consequences had stemmed from the use. During this phase, we observed that in addition to understanding why people used smartphones, how they used them emerged as essential for understanding their behavior and experiences. Thus, we also assigned the codes to a fourth group: 4) how the interviewees used their smartphones. As the final task during this phase, irrelevant initial codes were removed.

While our analysis was heavily data-driven, during the coding process we harnessed theoretical insights from technostress and uses and gratifications literature to guide our coding. This meant looking for content in the participants' words that resonated with concepts central to the literature streams (e.g., specific types of technostressors such as *overload* and gratifications such as *entertainment*). Such central concepts were used for categorizing the codes when we started combining the codes, creating categories based on them (Saldaña, 2013). For example, the codes *too much content to browse* and *an overflow of information* were categorized under *information overload* (later re-named as *online information overload*). In line with prior studies, we identified online information overload as a technostressor (this is an example; other technostressors were also identified). Therefore, we harnessed existing research to deepen our understanding of the data (Saldaña, 2013). Based on our data, we observed three technostressors that previous studies had not identified: techno-procrastination, online information bubbles, and gratification mismatch. Moreover, as we wanted to understand how individuals used their smartphones, we examined the codes relating to that, which resulted in, for example, the codes *immediately reads messages* and *instantly grabs the phone during downtime*, which were categorized under the *instant dimension of use*. This approach was applied to other concepts as well. For example, the codes *one can shut off the brain* and *one can take a breather* were consolidated under the category *relaxation*, which was identified as a hedonic gratification. Similar actions were performed for the other dimensions of use, gratifications sought and obtained, and strains/other outcomes. We categorized the codes iteratively and compared the new categories with the original codes and the data to ensure that the categories were loyal to the data (Lune & Berg, 2017; Saldaña, 2013).

Next, the first author re-read the whole data set, reflecting the created codes and categories with the data, ensuring that the codes and categories created could capture the essence of what the interviewees said. During this phase, the data, codes, and categories were constantly

compared, and if needed, the codes and categories were reorganized or removed (Saldaña, 2013). As our goal was to explain how different concepts are linked, we searched for patterns within the data (Lune & Berg, 2017). We analyzed how specific ways (dimensions of use) and reasons (gratifications) associated with smartphone use were present in certain negative situations (technostress) and vice versa. For example, the interviewees could tell that they were seeking entertainment and, therefore, browsed their smartphones continuously, due to which they neglected other tasks. This was also done in the other direction. The interviewees could tell that they experienced exhaustion due to the constant flow of messages (information overload) from different services. By examining the data, such situations could be pinned down to, for example, versatile use performed to obtain social gratifications. To understand the phenomenon holistically, the authors together analyzed the relationships between the different categories and based on the resultant observations and discussions, created a model to explain the emergence of technostress in the context. The findings identified as central were those corroborated by multiple participants, thereby enhancing the validity and reliability of the conclusions through triangulation (Lune & Berg, 2017). Additionally, the robustness of these findings was further reinforced by employing constant comparison, which involved iterative analysis of the data, codes, and categories. This process allowed for the refinement, reorganization, or elimination of codes as necessary to ensure they accurately reflected the essence of the participants' responses (Saldaña, 2013). Moreover, this enhanced the concisteny of our coding and analysis, further increasing the validity and reliability.

Next, we will present our observations on smartphone use and the associated gratifications. Following this, we will explore the interplay between the dimensions of smartphone use, the gratifications sought and obtained, and the experience of technostress. We provide brief information about the frequency of observations where relevant (e.g., how many participants mentioned a particular technostressor). However, we emphasize that these numbers are presented solely as background information and should not be used to draw generalized conclusions.

RESULTS

Smartphone Use Loop

As we were analyzing different dimensions of smartphone use and gratifications sought and obtained in our data, we observed them forming a cycle: *the smartphone use loop*. This loop illustrates how gratifications sought, dimensions of smartphone use, and gratifications obtained are associated, with the gratifications sought serving as the trigger that initiates smartphone use, followed by the dimensions of use, leading to the gratifications (not) obtained (visualized in Figure 2). In the following sections, we discuss the smartphone use loop in more detail. We will begin by discussing gratifications sought and obtained, as gratifications sought act as the trigger that initiates smartphone use. Subsequently, we elaborate on the different dimensions of smartphone use. Finally, we will illustrate how the smartphone use loop can be employed to explain the emergence of technostress, extending existing research on the antecedents of technostress.

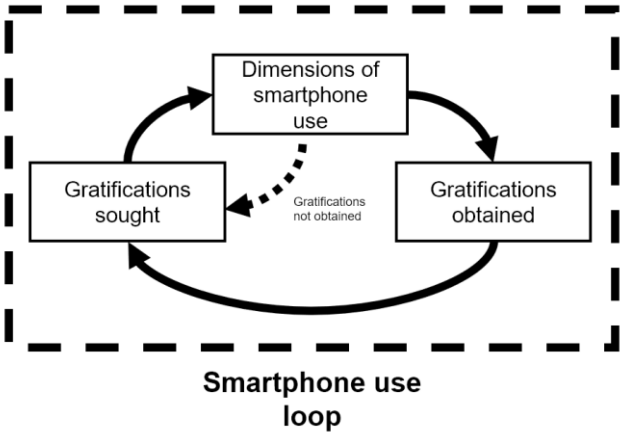

Figure 2. Smartphone Use Loop.

Gratifications Sought and Obtained

Previous studies have suggested that media users may not always obtain the gratifications they seek (Palmgreen, Wenner & Rayburn, 1980; Rokito et al., 2019). Therefore, we provide insights from both scenarios. We divide gratifications into three main categories: hedonic, social, and utilitarian. While all 30 interviewees sought and obtained gratifications across these main categories, differences were observed in terms of more specific gratifications.

Hedonic gratifications. The most prevalent hedonic gratifications sought and obtained among the interviewees concerned entertainment. Moreover, they pursued gratifications like escapism, relaxation, novelty, humor, passing time, comfort, and inspiration. Entertainment was especially sought in situations the interviewees considered boring, and social media platforms like Instagram and TikTok were frequently used for this purpose. Many highlighted that visual content, such as pictures and videos, were the primary sources of hedonic gratifications, and such gratifications were often sought by continuously browsing different kinds of feeds. In cases where escapism was sought, users tended to access their smartphones repeatedly, checking various social media feeds for novel content. Many interviewees thought smartphone use could initially bring hedonic gratification, although after continuous sessions or repeated browsing, the gratifications were no longer perceived as obtained. Overall, we found that hedonic gratifications were the most frequent types of gratifications associated with situations leading to technostress. Nevertheless, hedonic gratifications were frequently pursued through browsing various digital content feeds. As one participant described their experience of reading comments on a social media platform:

> *And it's fun, and you find those highlights there, like everyone's always trying to be so funny, but you also come across things that are genuinely funny. So, it's nice and entertaining. [...] It's like entertainment, and specifically in a fun way.*

Social gratifications. The most prevalent social gratifications sought and obtained among the interviewees concerned social connection. Moreover, they pursued gratifications like affection, staying up to date with their friends and relatives (by instant messaging or through following them on social media), and other elements of sociality, including peer support. In our interviews, different aspects of sociality were the most common reasons for smartphone

use. Many interviewees mentioned that their close ones lived elsewhere, and staying in touch with them was a primary motivation for smartphone use. Some highlighted active communication, while others emphasized the ability to observe what people were doing. Instant messaging (mainly WhatsApp) was primarily used for social gratifications, although some interviewees used social media like Instagram and Facebook for this purpose. Overall, the ability to send and receive messages instantly was highly valued, often leading to instant and repeated checking of smartphones. Additionally, smartphones offer a versatile means of managing different social environments, and many interviewees used various social media and instant messaging services for different people or social situations, allowing them to tailor their interactions accordingly. In general, the interviewees reported that they were successful in obtaining the social gratifications they sought. However, there were instances where the gratifications sought were not obtained, such as when they were waiting for a message but not receiving it. For the majority of participants, social gratifications emerged as the most significant drivers of their smartphone use:

> *Yeah, the social aspect, like staying in touch with people, that's definitely the most important thing. It's really the only reason why I even pick it up. It's the social side... Okay, sometimes it's for a Google search or something like that, or listening to music or something else, but like, 90 percent of the time, it's about that social connection. Or seeking it there. I'm quite a people-oriented person, so even though I spend a lot of time alone in my daily life, in a way I'm not, because through the phone, I'm still connected to people.*

Utilitarian gratifications. The most prevalent utilitarian gratifications sought and obtained among the interviewees concerned staying up to date. Additionally, other information-related gratifications were mentioned. Often, the interviewees actively pursued information on specific topics, but they also passively absorbed information while browsing news and social media feeds for various purposes. Many interviewees turned to different news sources to enhance their understanding of global and national events, reflecting their desire to stay up to date. Moreover, social media was commonly used to gather information on various topics, often accomplished through personalized browsing. In general, the interviewees reported that they were usually successful in obtaining the utilitarian gratifications they sought, although personalized use sometimes hindered this by limiting exposure to a broader range of information. Even though the utilitarian gratifications sometimes played a role in prompting the browsing of digital content feeds, their role was not as influential as that of the hedonic and social gratifications in our data. Still, especially utilitarian gratifications linked to staying up to date were often mentioned, as one participant explained on browsing news sites:

> *Mainly, I still want to browse them because I know they provide at least some good information. And then again, even for my work, it's important to stay updated on things like economic events. So, in a way, I don't see it as negative or a waste of time; for me, it's just a given that I stay informed about those things every day.*

It is important to note that all the main gratifications discussed can be sought or obtained simultaneously. For instance, some social media platforms are used for entertainment, communication, and information-seeking purposes, making them relevant to all the gratifications discussed. Indeed, by communicating with others (seeking social gratifications), users might simultaneously obtain both hedonic (enjoyable conversation) and utilitarian (useful

information exchange) gratifications. Next, we discuss the different dimensions of smartphone use that were prevalent in our data in more detail.

Dimensions of Smartphone Use

From our data, we identified five dimensions of smartphone use. The dimensions of use provide insights into how smartphones are used; what is characteristic of the use, addressing both temporal (instant, repeated, and continuous) and content (personalized and versatile) characteristics. Thus, the dimensions do not focus on specific activities or tasks performed on the device.

Instant. This dimension refers to situations in which users instantaneously initiate smartphone use by reacting to various stimuli, such as receiving a smartphone notification, or situational cues, like watching TV and encountering commercials. Therefore, instant use can be triggered by either smartphone-related events or real-life occurrences. Within the instant dimension of use, only a single use instance takes place. For example, users might read a message they receive on their smartphones immediately after receiving it or instantly engage with their smartphones when the current activity lacks stimuli. The gratifications sought are especially relevant in explaining the initiation of instant use. One interviewee provided an example of using their smartphone while eating or waiting in queues:

> *Like when you're eating, you feel like you need your phone there, or standing in a queue at the store. I mean really brief moments, it doesn't have to be very long, that moment of boredom or pause, for you to take up the phone.*

Repeated. This dimension refers to situations in which users repeatedly use their smartphones, such as frequently checking their devices to browse social media or to see if they have received any messages. Within the repeated dimension of use, multiple instances of use take place, and repeated use can reflect multiple instances of instant use. Both the gratifications sought and obtained play a central role in repeated use. Gratifications sought initiate the use, and when the gratifications are obtained, users may seek to experience them again, leading to repetitive actions. The same can occur if users do not obtain the desired gratifications because they may repeat their efforts to attain the gratifications they originally sought. The interviewees often engaged in repeated smartphone use in situations they found otherwise uncomfortable. For instance, interviewees mentioned their tendency to repeatedly access smartphones while trying to study:

> *But sometimes, you kind of wake up to the fact that you repeatedly pick up your phone and open, say, a messaging app or Reddit several times, and you're like scrolling through it for, say, five minutes, then you put it down and then pick it up again, put it down, pick it up again.*

***Continuous*.** This dimension refers to situations in which users browse their smartphones continuously over an extended period. In continuous use, a single or multiple use instances can occur, meaning that both the instant and repeated dimensions can eventually transition into continuous use. This may happen, for example, when a user receives a message, immediately reads it, and then continues using the phone. Continuous use is particularly characteristic when browsing social media, as these platforms typically feature feeds containing an endless stream of content (such as TikTok), allowing users to browse without reaching a natural stopping

point. In continuous use, the gratifications obtained are crucial in maintaining engagement. As one interviewee mentioned about TikTok and the novel content it constantly displays:

> *Like, if I sit down on the couch and decide, "okay, I'll open TikTok and watch a couple of videos, just for a moment." But because it's so easy to use, and there's always new videos coming up, then suddenly I realize how easily I can get stuck there for half an hour.*

Personalized. This dimension refers to situations in which users engage with digital content feeds that are personalized by the service to appeal to individual users. Differing from instant, repeated, and continuous dimensions, the personalized dimension does not address the temporality of use. An example of personalized use is when users browse social media feeds that feature content personalized by the service to align with the presumed interests of the user. In personalized use, the gratifications sought and obtained are often aligned, at least initially, as such use is supposed to be consistent with what the users are interested in. However, due to personalization, users may not always see everything they truly want. Nonetheless, personalized use in services such as TikTok was often found to be entertaining, as one interviewee noted:

> *I initially thought, "this isn't for me" [TikTok]. But for some reason, I wanted to explore it further, and I started responding to those videos, by clicking "I don't like this, and I don't like that" on some, so it started customizing the front page based on that. And then I realized, "Okay, there are actually some funny videos here," and I realized I was using it every day.*

Versatile. This dimension refers to situations in which users engage with more than one digital content feed. Differing from instant, repeated, and continuous dimensions, the versatile dimension does not address the temporality of use. In versatile use, the gratifications sought are particularly important. Given that individual feeds or functionalities within feeds may not be capable of fulfilling all the gratifications users seek, versatile use becomes necessary. One interviewee elaborated on this in the context of reading news:

> *If I read, for example, [a magazine focused on the economy], I expect to get relevant information and news from there. And then with [a tabloid magazine], it's more like general, light news about what's happening in Finland, but it's not always purely informative; it has more entertainment value. But then, for example, I follow [a local newspaper] because it's a media outlet from [a county], and I live in [a city], so I still kind of keep up with news from my hometown.*

It is important to note that different dimensions of smartphone use can coexist and interact with each other. An example of this interaction occurs when users continuously browse personalized social media feeds, and this continuous use can lead to even more personalized information, reinforcing the personalized use dimension. Nevertheless, specific dimensions tend to be more prevalent in some situations. Even more importantly, depending on the situation, specific dimensions of use, associated with different gratifications sought and obtained, play a crucial role in the emergence of technostress, which we will elaborate on in the following sections.

Interplay Among Technostress, Gratifications Sought and Obtained, and Dimensions of Use

In this section, we explain the interplay between technostress, gratifications sought and obtained, and the dimensions of smartphone use (as illustrated in Figure 3). Our observations reveal that the gratifications sought initiate the process, followed by engagement within a specific dimension of smartphone use. Depending on various situational factors, smartphone use may lead to the gratifications obtained or not obtained. However, it is crucial to note that technostress can emerge in both scenarios. Following Figure 3, we explore the two distinct routes that illustrate the associations between technostress and the smartphone use loop. In Table 1, we have summarized central situations that follow the model. Moreover, Table 2 presents an example chain of evidence of our results.

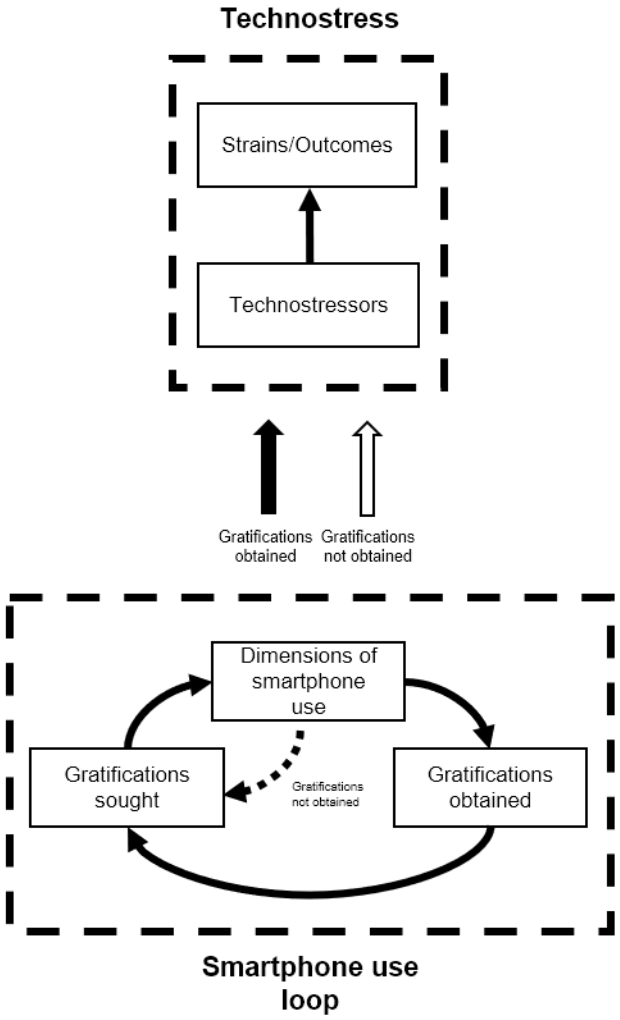

Figure 3. Smartphone Use Loop and Technostress.
Note. The gratifications sought, dimensions of smartphone use, and the gratifications obtained may interact without leading to technostress—the figure illustrates how the smartphone use loop can underlie situations in which technostress emerges.

Table 1. Central Situations of the Interplay Among Technostress, Gratifications Sought and Obtained, and Dimensions of Use.

	Situation 1	**Situation 2**	**Situation 3**	**Situation 4**	**Situation 5**
Dimensions of Smartphone Use	Instant	Repeated	Continuous	Personalized	Versatile
Central Gratifications	Hedonic gratifications sought **and** obtained	Hedonic gratifications sought **and** obtained	Hedonic gratifications sought (**but not**) obtained	Utilitarian/ social gratifications sought **but not** obtained	Social gratifications sought **but not** obtained
Central Technostressors	Interruptions; techno-invasion	*Techno-procrastination*; online information overload	*Gratification mismatch*; techno-dependency	*Online information bubbles*; negative life comparison	Online information overload; fear of missing out
Central Strains/Outcomes	*Worsened boredom tolerance*; frustration; annoyance; fatigue	Anxiety; exhaustion	Guilt; sleep problems	Fear; inadequacy	Exhaustion; anxiety
Situation Description	Despite obtaining gratifications related to, for example, passing time, instant smartphone use leads to interruptions and eventually, worsened boredom tolerance (e.g., due to being so used to instant gratification).	Despite obtaining gratifications related to, for example, escapism, the individual's repeated smartphone use leads to techno-procrastination and anxiety (e.g., due to not progressing important tasks).	Despite initially obtaining gratifications related to, for example, entertainment, continuous smartphone use eventually is not gratifying, leading to gratification mismatch and guilt (e.g., due to spending time on something that is not gratifying or important).	Due to personalized use, one encounters online information bubbles and is unable to see different perspectives for information, which can increase fear (e.g., of polarization).	Due to versatile use, one encounters online information overload, which can lead to exhaustion (e.g., due to too much information coming in from different social media platforms and instant messaging services).

Note. Technostressors and strains in italics are new findings.

Table 2. An Example Chain of Evidence: Situation 1.

Interviewee	Dimension of Smartphone Use	Central Gratifications	Central Technostressors	Central Strains/Outcomes
A woman in her 30s, holding a Master's degree, and working full-time. She perceives her smartphone proficiency as good and uses her smartphone for 3-4 hours daily. She primarily uses various types of social media, like Instagram and Pinterest, as well as instant messaging services such as WhatsApp. She frequently browses news sites on her smartphone and occasionally uses an online dating application.	"I do notice that if the phone is right there next to me, I'll pick it up without even really realizing it. Before I know it, I've grabbed it, opened it, and started scrolling through something." **(instant)** "But somehow it feels like everything has become short and fast, like… Communication has changed to be like that." **(instant)**	"It's so easy to check it during a commercial break or even in the middle of a show, and without even thinking about it, you might just grab the phone and start using it." **(hedonic gratification sought and obtained – passing time)** "And it's exactly that thing with those services, where there's always something new. So, it's always like, 'Oh, let me refresh one more time, maybe there's something else here.'" **(hedonic gratification sought and obtained – novelty)**	"And actually, just this spring I realized that I was getting every possible news notification on my screen, and then with a smartwatch on top of that, those notifications would vibrate on the watch too. I noticed how much attention it took—like, even if the news wasn't particularly interesting, I still ended up looking at it." **(interruptions)** "I usually love reading books while on vacation, but I realized that I couldn't focus on them at all. Before, I would easily get immersed and read for hours, but now it was so fragmented [due to smartphone use]. I even started wondering if my brain had completely deteriorated." **(techno-invasion)**	"And also, noticing that the ability to tolerate boredom is really poor. That's probably the most concerning thing, that you constantly feel the need for stimulation. That's probably not such a good thing..." **(worsened boredom tolerance)** "I also notice that it's quite overwhelming if I'm constantly following the day's news events in real time throughout the day. It definitely adds to the mental load." **(fatigue)**

Technostress and Smartphone Use Loop - Gratifications Sought and Obtained

First, we showcase situations in which users actively sought and successfully obtained gratifications but also encountered technostress. As a key aspect of our study was to gain insight into the driving forces of smartphone use that ultimately contribute to technostress, we inquired about the reasons for smartphone use with all our interviewees. Many promptly offered explanations that encompassed the purpose of their use (gratifications sought), how they engaged with their devices (dimensions of use), the resulting benefits (gratifications obtained), and concurrent experiences of technostress. To illustrate, one interviewee described her smartphone use, including the ensuing frustration and annoyance:

> *Primarily, it's about seeing what friends are up to, how they're doing. Also, it's for inspiration and sometimes also for seeking information. On the surface, it sparks curiosity and brings a good mood, but sometimes it also leads to* ***frustration*** *and* ***annoyance.***

Among our interviewees, the most frequently sought-after gratifications centered around various social aspects. For instance, when individuals pursued social connection (social gratification sought), they often engaged with their devices instantly or repeatedly (dimension of smartphone use). In cases of instant use, technostressors related to interruptions and invasion (and the associated constant availability) were particularly prevalent. Constant availability was a recurring topic, with many describing it as exhausting, frustrating, or annyoing (15

interviewees). Yet the associated instant and repeated use were seen as something that is expected of them, serving a crucial purpose in obtaining social gratifications:

> *It's really important [social gratifications] in a way that you feel like if you're not on your phone or if you don't see people's events and also don't report on your own life, then somehow you might be forgotten. [...] It's like it's a natural way to stay connected, and there's a lot of commenting through private messages, so it's not just passive scrolling, but also active discussions taking place there. [...] Yeah, I feel it's quite* ***exhausting****, having to be present all the time. It's maybe also, I'll add to the negative aspects, um, negative aspects somehow, this* ***need to be present all the time****. It's like this constant thought that you have to respond quickly, and even if you've seen a message and you're online, you don't respond, so it creates this strange, um,* ***pressure to act in a certain way****.*
>
> *But now there's this expectation for real-time communication [on an online dating service]. And I feel like it's really* ***exhausting****, like you're supposed to always be available. And if you're not, then it's like, onto the next one [laughs]. Like, they expect... That constant real-time connection, always having the phone in your hand. It's kind of* ***distressing****... There are so many factors that made me decide it's better to just let it go, because it's...* ***It takes more than it gives.***

In addition to social use, passing time with smartphones was highly prevalent in our data. This often occurred during brief moments when no other engaging activities were available. Associated with instant use, many interviewees (seven of them) reflected how their ability to tolerate boredom had decreased, which we see as an outcome of technostress. Even when users were able to pass the time using their devices, involving both gratifications sought and obtained, such behavior could still lead to technostress. Although this could emerge from a single instance of instant use, it was particularly common when use was repeated. This could create a vicious cycle: smartphones were used to alleviate boredom, but smartphone use might worsen the ability to tolerate boredom, leading to increased use. Overall, many interviewees expressed extreme annoyance with their decreased tolerance for boredom. Furthermore, in situations where hedonic gratifications were sought (as opposed to social gratifications), the interviewees did not seem to place as much value on obtaining them despite the momentary entertainment provided. As these two examples show about passing time using a smartphone and the associated issues with boredom tolerance:

> *I even felt like not watching TV shows. Somehow, it felt like even when watching series, or at least during the commercials if you watch TV, or if you're watching Netflix there might be a boring part. So,* ***I might pick up my phone and start looking at it, it was really hard…***
>
> *Like, whenever there's a moment where there's nothing to do, the phone is always in your hand, and you feel the need to send a message to someone or constantly be in contact with someone. It's kind of* ***overwhelming****, at least for me. And I've noticed that nowadays, my* ***lack of focus is really concerning****. For example, I can't even watch a full Netflix episode, not even a 20-minute one. At some point, I realize I've picked up my phone again.* ***I just can't maintain focus.***

More specifically, many interviewees resorted to using their smartphones repeatedly and continuously to escape uncomfortable or even stressful situations. Such behavior could lead to something we call "techno-procrastination", where individuals delay engaging in other activities by using their smartphones, reported explicitly by ten interviewees as a stress-creating condition. In these scenarios, users are typically able to obtain various hedonic gratifications, such as entertainment or simply escapism. Trying to escape uncomfortable situations by using a smartphone might provide momentary gratification but could be detrimental in the long run by prolonging the stressful situation:

> *And you know, that's actually* ***one problem;*** *if there's a situation that becomes too* ***stressful****, I'd rather escape to my phone than try to face the problem, and then* ***confronting the problem gets delayed.*** *[...] Yeah, I get that momentary feeling of relief, but then I feel terrible again when I return to real life, and I immediately want to escape back. [...] So, I just* ***prolong being stressed...***

Also, many interviewees highlighted how smartphone use often led to the postponement of their sleep patterns, where continuous use was central. In fact, 16 participants mentioned that smartphone use could contribute to issues with sleeping. Thus, while not everyone who used their smartphones continuously during the night considered it problematic, it had caused issues for the majority. The gratifications sought during such situations were often hedonic, and they were obtained by browsing content that was considered entertaining, amusing, and interesting. In such cases, the gratifications obtained were enough to keep them engaged with the devices, contributing to continuous use. However, despite obtaining the gratifications, less sleep was considered a problem:

> ***It has disturbed [my sleep].*** *[…] It's probably the evening-oriented [use]. I'm already a night owl, so then I notice that, if it's the last thing before going to sleep, I open some social media and start looking at it. Or well, the last mistake is to start watching a YouTube video and then realize three hours later that I'm still staring at a YouTube video. So, it's definitely [laughs]* ***a problem for me*** *that I'm maybe a bit easily swayed by interesting content.*

In addition to social and hedonic gratifications, the interviewees used smartphones to stay up to date with news and current events. While this behavior was not as typical in our data, most interviewees did browse news concerning topical issues nationally and worldwide. Such was often done repeatedly because they wanted to stay informed about what was happening in real time. Additionally, versatile use was often engaged in due to different news sources providing different types of news. Even when the gratifications sought were obtained, browsing news could contribute to stress and anxiety due to the vast amounts of often negative information. While stress can be caused by news from various sources like TV or newspapers, it is emphasized in the context of versatile smartphone use because users have instant access to sources reporting on events worldwide. Nine interviewees discussed the stressful experiences they had had in relation to reading news on their smartphones. As one interviewee explained, she had experienced high levels of stress from following news online, despite wanting and being able to stay up to date:

> *Well... I easily get* ***stressed*** *about the state of the world, and often, the news doesn't really focus on the positive things, so... I get this* ***anxiety*** *from all the bad news*

> *happening around the world or in Finland. So, that's why I don't actively read the news. [...] I mean, I would like to stay up to date with what's happening in the world, but then when you force yourself to go through all the pages [of different Finnish news outlets], it just* ***becomes stressful... It's just stressful. And it makes you feel bad.*** *So then I've realized that, well, I don't have to read them.*

To summarize, obtaining gratifications does not inhibit experiencing technostress in smartphone use. While gratifications can sometimes alleviate negative feelings, this depends on the specific gratifications. The interviewees appeared to assign different values to various gratifications, which in turn influenced the technostress experienced (for example, social gratifications were seen as more important than hedonic ones). We emphasize that both the "whys" (gratifications sought and obtained) and the "hows" (dimensions of use) are important in understanding the emergence of technostress in this context. Next, we will discuss situations where gratifications are sought but not obtained, associated with technostress.

Technostress and Smartphone Use Loop - Gratifications Sought but not Obtained

Situations in which individuals seek but do not receive gratifications can happen in two ways. First, users may immediately realize they are not obtaining gratifications. For instance, this can happen when users wait for a message and check their device but find no new messages. Second, users might initially obtain the gratifications they seek, but over time (during a single session or over multiple sessions), these gratifications are no longer obtained. Such a mismatch of gratifications sought and obtained can be stressful because it creates a conflict within users regarding their behavior. Many interviewees said that continuously and repeatedly browsing social media feeds caused this, and they eventually stopped experiencing gratification, which elicited emotions like guilt, which was reported by seven interviewees. As one of them described:

> ***You start feeling a bit guilty****, like maybe you could have used this time for something more productive. [...] You occasionally think that, "Okay, it's actually good [browsing the smartphone]," that it's sort of like, for example, sometimes when it's in the evening before going to bed, it's kind of like a reset time. Even if you watch videos on YouTube or just browse something, it's like a way to reset yourself, especially if you've had something on your mind during the day, or you just need to unwind. That's okay.* ***But then, if you notice that you do it too often, you start feeling a bit guilty****, like, "Come on, you have resources to use for maybe something a little better, so use your time for something else sometimes."*

While gratification mismatch is a common factor contributing to technostress in the situations discussed in this section, it is not the sole cause. For example, many interviewees browsed their smartphones in personalized fashion to find content about their interests, which could lead to them encountering online information bubbles. These bubbles can inhibit people from seeing content from a different perspective, resulting in gratifications not being obtained. Many interviewees believed that only being exposed to information solely from one perspective is harmful, as it can contribute to, for example, increased polarization. As the

following quote illustrates, one interviewee expressed concern and even fear about online information bubbles while nine interviewees in total discussed similar issues:

> *When I started thinking about how much I've actually chosen myself, like where I join, and how much has come as a sort of feed, like "oh, that looks interesting, let's go there". And through that,* ***my own thinking has been reinforced and maybe even changed in some ways****. [...] So, if I hadn't been on these channels at all, how different a person would I be? Do these essentially shape or produce certain kinds of people? It's kind of a wild thought [...] So, it's kind of, even a bit* ***scary****.*

Personalized use can also contribute to technostress when individuals browse different digital content feeds to follow the lives of others. For instance, many experienced technostress when following the seemingly perfect lives of "influencers". While following such content can be inspiring, it can also have the opposite effect due to unfavourable comparisons. Algorithms often show users more of this type of content, which creates more opportunities for stress-inducing comparison behavior. In total, 16 interviewees discussed technostress relating to negative comparison behavior. The following quote provides an example of negative comparison and users' interests:

> *If you've been a bit down in general, maybe it doesn't really help* ***when everything is, like, fantastic, and everyone seems so productive****, and I'm just sitting here scrolling through social media. [...] When I do handicrafts, it always felt like* ***no matter how amazing I made something, someone had made something much more amazing, and someone took better photos, and everyone seemed to have a slightly better relationship****. Or at least it looked like it because, you know, that's how it is, it's not exactly pressure, well, maybe pressure is the wrong word. But maybe a feeling of* ***inadequacy****. So, it's been kind of, and then somehow like, "Well, why am I knitting when my socks never look like that other person's socks?" or, "Why am I running to work every day when that one person runs 250 kilometers?" Like I should somehow reach their level.*

On a different note, many interviewees reported using different communication applications. When multiple applications are used, the overall information load can become exhausting. While a single application or service can contribute to technostress, the interviews showed that the potential for negative consequences increases when users engage in versatile use. When users receive too much information from multiple sources, it can become challenging to obtain gratifications because not all information is relevant. This overload, reported by 18 interviewees, can make it too challenging to find the information that is genuinely valuable, resulting in a burdensome and exhausting experience:

> *In my free time too, it's like wondering if there are Snapchat messages or Instagram notifications, or maybe something on LinkedIn or elsewhere. [...]* ***So, yes, notifications come in a lot per day. In fact, I checked, and I've had 181 notifications on my phone screen today****. [...] Well, I think to some extent, now that there's an unlimited amount of information available, it does start to become* ***burdensome*** *at some point... After all, the amount of absorbable information is quite limited per day, what you can take in, and then it keeps adding more information every hour of the day, so it does start to become* ***exhausting*** *at some point.*

Furthermore, several interviewees mentioned using multiple services to avoid missing out on anything. Paradoxically, while versatile use is often done to mitigate FOMO (in total, 15 interviewees discussed FOMO), it can also increase this fear because there are so many different gratifications being sought. If an individual seeks to see everything across various social media platforms, instant messaging services, and news sites, it becomes easy to overlook something and, as a result, miss an opportunity to obtain gratifications, which can lead to technostress:

> *Some stories [Instagram], for example, are only there for 24 hours and then disappear. There is a feeling of **FOMO**, like, you want to stay on top of things and want to see the information when it is still available. [...] Unless there's something like "I would have asked you to eat [with me]", of course **it's annoying** when you've missed something just because you haven't been checking your phone [instant messaging]. [...] And I wanted Snapchat because all my friends were on Snapchat, it felt like **I was missing out on so much** because I wasn't there.*

Summary of the Results

To summarize, the situations discussed represent some of the possible interactions among gratifications sought and obtained, dimensions of smartphone use, and technostress. While they are not an exhaustive list, they were central in our data. Based on them, we developed a model that illustrates the various concepts and their relationships. We made two important distinctions: whether gratifications sought are obtained or not. In both scenarios, technostress can emerge, but the nature of these situations differs. Obtaining gratifications does not necessarily eliminate technostress; however, it can help mitigate negative thoughts and emotions associated with it. Gratifications, both sought and obtained, provide insights into users' cognitions in relation to technostress in smartphone use. For example, the experienced strains and other outcomes of stress seemed to differ when comparing situations where gratifications were obtained (e.g., when gratifications are not obtained, guilt is often present in continuous use). Additionally, the dimensions of use can play a role in whether gratifications are obtained, thus affecting the experienced technostress (e.g., personalized or versatile use can actually inhibit obtaining gratifications, contributing to technostress), highlighting the holistic effect of the smartphone use loop in the emergence of technostress. In Table 3 below, we have compiled our new findings for the context of technostress.

Table 3. Summary of New Findings in the Context of Technostress.

Finding	Description
1) Gratifications sought, gratifications obtained, and the dimensions of smartphone use form a smartphone use loop that is crucial for understanding behavior underlying technostress experiences in smartphone use	The concept of smartphone use loop integrates both the whys and hows of smartphone use in technostress situations/experiences. For example, when a user seeks social gratifications and instantly engages with their smartphone disrupting the task currently at hand, such can lead to technostress (e.g., due to techno-invasion). If gratifications are not obtained, the positive feelings are not present to alleviate the stress. Furthermore, by seeking the gratifications again, the user can engage in repeated use that can lead to "more" technostress (e.g., due to techno-procrastination).
2) Gratifications sought and obtained provide insight into users' motivations for smartphone use in technostress situations/experiences	Hedonic, social, and utilitarian gratifications sought and obtained provide insight into why smartphones are used when users experience technostress. When users obtain gratifications they value highly, technostress experiences are not as prevalent (e.g., social gratifications emerged as most valued in our study). Furthermore, not obtaining gratifications can contribute to (increased) technostress. Thus, technostress experiences can differ based on the gratifications sought/obtained and whether the gratifications sought are obtained.
3) Dimensions of smartphone use provide insight into users' nature of activities performed to interact with information delivered via smartphones in technostress situations/experiences	We identified five dimensions of smartphone use (instant, repeated, continuous, personalized, and versatile) that provide insight into how smartphones are used when users experience technostress. The dimensions do not directly reflect technostress situations/experiences, but they provide insights into behavior that can contribute to technostress (e.g., personalized use can be stressful when users encounter online information bubbles).
4) Delineating technostressors and strains/other outcomes previously unidentified	Gratification mismatch, online information bubbles, and techno-procrastination emerged as technostressors previously unidentified in research. Furthermore, worsened boredom tolerance emerged as a negative outcome of technostress.

DISCUSSION

Research Contributions

This study makes three key research contributions. First, we combine theoretical insights from two distinct research streams, namely, uses and gratifications theory and technostress. Our approach enables a comprehensive examination of why and how personal use of digital content feeds on smartphones can lead to technostress. Previously, studies have examined the impact of personality traits (e.g., Hsiao, 2017; Lee et al., 2014) or IT characteristics (Ayyagari et al., 2011; Salo et al., 2019) on the emergence of technostress. However, technostress research has primarily focused on technostressors (e.g., overload) and their resulting strains (e.g., fatigue) or other outcomes (e.g., discontinued use) (Sun & Lee, 2022). We expand this perspective by investigating gratifications, which can be understood as underlying cognitions associated with technostress experiences. While the uses and gratifications theory has been previously applied in studies discussing the negative consequences of IT use (e.g., Baabdullah et al., 2022; Chaouali, 2016; Gentina & Rowe, 2020; Sun et al., 2020), we explain gratifications and technostress from a dual perspective following Palmgreen and Rayburn (1979): gratifications sought (closely tied to needs or motives) and gratifications obtained (satisfying needs by

receiving gratifications). Extant research has shown, for example, that users may not want to stop using IT due to the possibilities for obtaining hedonic gratifications, even though overall use may be harmful (Salo et al., 2022). We add to these findings by explaining how gratifications beyond the hedonic type may have similar effects. For example, when individuals engage instantly, repeatedly, or continuously with their smartphones and feel overloaded and exhausted due to the messages they send and receive, they nevertheless obtain social gratifications and wish to continue their use as the gratifications are highly valued.

We relate our findings to existing literature on technostress and smartphone use by building on prior discussions of types of smartphone use, such as using instant messaging for social, work, and study purposes, and their connections to technostress (Ardèvol-Abreu et al., 2023). Expanding on this, we explicitly examine the roles of dimensions of use and gratifications sought and obtained in the emergence of technostress, providing a more nuanced understanding of these relationships across a broader range of personal use contexts. Moreover, previous research has shown that using social media can be simultaneously stressful and enjoyable, and the users need to evaluate the balance of stress and various positive consequences (Ardèvol-Abreu et al., 2023; Cheikh-Ammar, 2020; Steelman & Soror, 2017). Regarding such a balance, we observed that smartphone use associated with social gratifications might align better with users' values than hedonic-oriented browsing which affected the technostress emergence. However, even more prevalent was that technostress was experienced when no gratifications were obtained, meaning that gratifications could alleviate technostress. Thus, we extend on the previous findings that not obtaining gratifications sought can, for example, contribute to fatigue when using social media (Ravindran et al., 2014) by offering more detailed explanations from the perspective of technostress and by discussing the effect of dimensions of smartphone use in the relationship between gratifications sought and obtained. Such findings contribute to existing technostress literature by providing new ideas into how the technostress process unfolds through cognitive antecedents.

Moreover, although the objective of this study was not to explicitly categorize technostress experiences based on demographic factors, some nuanced observations emerged in this regard. For example, participants who reported living with a partner frequently noted that their own or their partner's smartphone use had contributed to tension within their relationship. While previous studies have shown that technostress can manifest as issues to social relations (Salo et al., 2019), understanding the role of gratifications sought and obtained for technostress in such situations provides us with deeper insights into the situation. If smartphone users receive gratification from their use but simultaneously harm their relationships, such could call for a more explicit prioritization of one's cognitive patterns.

Second, we treat uses and gratifications as separate constructs and introduce the concept of smartphone use loop. We emphasize the importance of this distinction because the dimensions of use and gratifications are separate yet interconnected concepts, which can help us in discerning the "whys" and "hows" of smartphone use contributing to technostress. To address the "hows," we develop an explicit categorization for the dimensions of smartphone use, defined as the nature of activities users perform to interact with information delivered via smartphones. This categorization comprises five dimensions: instant, repeated, continuous, personalized, and versatile. Although some of the dimensions are present in IT on a broader scale (e.g., the Internet), we find that our dimensions together reflect what is characteristic of browsing digital content feeds on smartphones. The dimensions extend the existing body of

research on uses and gratifications theory by offering new insights for approaching use, which has typically been characterized at a more general level (e.g., ritualistic and instrumental use) (Rubin, 1984), or focused on different types of use derived directly from gratifications (e.g., entertainment use, social interaction, and information-seeking) (Ardèvol-Abreu et al., 2023; van Deursen & van Dijk, 2014). Furthermore, we add to previous studies that have focused on usage types (Bonds-Raacke & Raacke, 2010; Elhai et al., 2017) or user types (e.g., Brandtzæg, 2010). In related research, we notice some similarities between our dimensions and earlier findings. For instance, the amount of use (Blank & Groselj, 2014) aligns with the repeated dimension, and the extent of use (Maier, Laumer, Eckhardt, et al., 2015) corresponds to the continuous dimension. Moreover, constant use (Duke & Montag, 2017; Gerlach & Cenfetelli, 2020; Salo et al., 2022) could reflect both the repeated and continuous dimensions. However, for example, we see that repeated and continuous use are distinct from each other, which the term "constant" is unable to capture. Furthermore, we add to extant research by introducing dimensions not previously addressed. Overall, the dimensions do not directly reflect stressful experiences; instead, they can be seen as a part of the smartphone use loop which together with gratifications sought and obtained provide insights into cognitions and behavior that can eventually lead to technostress. This resonates with existing research stating that, for example, constant use is not inherently negative (Gerlach & Cenfetelli, 2020).

Since browsing dynamic digital content feeds on platforms such as TikTok can lead to time distortion and subsequent negative consequences (Roberts & David, 2023), it is crucial to understand how these negative outcomes unfold. Thus, we expand on existing research by explaining the processes through which such consequences emerge through the lens of technostress. With our dimensions of use, we also extend previous findings associated with compulsive and excessive use and technostress, which has been a common perspective especially centered around smartphone and social media use (e.g., Cao et al., 2018; Hsiao et al., 2017; Lee et al., 2014; Luqman et al., 2021). Repeated use may become compulsive, and continuous use may become excessive, but this requires users to perceive their behavior as uncontrollable or excessive, as per the definitions of compulsive and excessive use (Caplan, 2010; Luqman et al., 2017). As a part of the smartphone use loop, we observed the identified dimensions of use preceding a variety of different technostressors. With the instant dimension, interruptions, and invasion (e.g., Ayyagari et al., 2011) were central. In repeated and versatile use, especially online information overload (e.g., Fu et al., 2020) was highlighted. Furthermore, continuous use often contributed to or reflected techno-dependency (e.g., Salo et al., 2022). Personalized use was highlighted when the interviewees discussed negative life comparison (e.g., Fox & Moreland, 2015; Salo et al., 2019). Thus, although some of the observed technostressors are not novel, we contribute to research by delineating users' underlying behavior associated with them. Through the concept of the smartphone use loop, our findings contribute to existing technostress research by explicitly highlighting both cognitive and behavioral antecedents of technostress, as well as their varying associations with different types of technostress experiences. This approach provides insights into why distinct types of technostress emerge from specific smartphone-related activities.

Third, although many of the technostressors we discuss have been previously established in various studies, we recognize that previous research has not fully explored all potential technostressors. By shedding light on the interplay between dimensions of smartphone use, sought and obtained gratifications, and technostress, we observed that a mismatch between

sought and obtained gratifications can manifest as a technostressor. When individuals seek specific gratifications from their smartphone use, for example, by continuously browsing social media feeds and do not obtain them, this can be stressful (e.g., leading to feelings of guilt). Furthermore, we introduce two additional technostressors, techno-procrastination and online information bubbles, that have not been addressed in previous technostress research. Techno-procrastination shares similarities with the concept of cyberslacking, which has been discussed before (e.g., Güğerçin, 2020; Lavoie & Pychyl, 2001). For instance, technostress could lead to cyberslacking in workplaces. However, we view techno-procrastination as a distinct stressor that can contribute to technostress emergence (e.g., procrastinating important tasks by repeatedly browsing a smartphone). Additionally, while previously identified technostressor techno-invasion (Maier, Laumer, Eckhardt et al., 2015; Tarafdar et al., 2007) may overlap to some extent with techno-procrastination, the key distinction lies in the specificity of techno-procrastination, which addresses situations where smartphone use not only invades one's life but also leads the individual to neglect important tasks. Thus, the invasive nature of IT by itself is not the trigger for technostress. This can be especially evident when individuals repeatedly access their smartphones in search for hedonic gratifications. Furthermore, although online information bubbles (or filter bubbles) (Savolainen, Oksa, Savela, Celuch & Oksanen, 2021) have previously been associated with negative consequences related to IT use, to the best of our knowledge, they have not been conceptualized as a part of the technostress process before.

Regarding strains/other outcomes, we discuss "worsened boredom tolerance" as a strain/outcome of technostress. When individuals are so used to instantly and repeatedly accessing their smartphones (e.g., to check for messages), it might lead to them being unable to tolerate situations in which they are not receiving stimuli from their smartphones. Additionally, if individuals rely on smartphones to alleviate boredom while simultaneously perceiving that their smartphone use has diminished their capacity to tolerate boredom, this dynamic may perpetuate a cycle of increased smartphone use. This increase could manifest through shorter intervals tolerated without smartphone stimulation, more frequent instances of smartphone access, prolonged periods of continuous use, greater personalization in browsing behavior, and engagement with a wider variety of content types, thereby encompassing linkages to all the dimensions of use identified in our study. Moreover, boredom proneness has been linked to overload and fatigue in social media use (Whelan et al., 2020). Thus, the experiences of boredom and technostress may vary among individuals, as some people may be more prone to boredom. In summary, identifying new technostressors and strains is valuable for a more comprehensive understanding of stress that can arise when using different technologies in various contexts and ways. It underscores that technostressors and strains are not universally applicable and should not be viewed as "one size fits all".

Practical Implications

Different stakeholders could use our findings to understand and combat the negative effects of technostress in personal smartphone use. First, users themselves could learn from our results. With the help of our findings, users can, for example, reflect if the situations we discuss are relevant to them, and accordingly, assess the levels of technostress they might be experiencing due to certain dimensions of smartphone use. Moreover, users can examine the relationships between the gratifications they seek and those they obtain in relation to technostress to evaluate

if the use they are engaging in is actually rewarding. Thus, evaluating one's behavior based on the smartphone use loop could provide users with insight into their technostress experiences and the possibilities for mitigating them. Focusing on specific user groups, such as individuals whose studies or work are adversely affected by technostress, this study could provide valuable insights into the particular situations where technostress interferes with critical academic or professional tasks. These users might also explore alternative behavioral strategies to address and mitigate such challenges effectively.

Second, service providers could use our findings to design applications that take technostress into consideration since previous studies have shown that technostress may contribute to users' discontinued service use (e.g., Luqman et al., 2017; Maier, Laumer, Weinert et al., 2015). Many of our interviewees emphasized that they believed the services they use were purposefully designed to deliver stimuli that they find gratifying, which is why it can prove difficult to resist browsing, leading to issues. Even though service providers aim to ensure user engagement and profits, we believe that technostress is a phenomenon that could eventually prove harmful to providers, too. Thus, for example, social media providers should implement functionalities that make it easier and more transparent for users to manage their personalized use.

Third, although we studied the personal use of smartphones and technostress, our findings can also be helpful for employers. If users feel drained due to their personal smartphone use, such may also affect their performance at work. Our findings could help employers understand what kind of personal smartphone use, especially within working hours, is harmful and what kind could prove beneficial (e.g., small breaks to release tension). In addition, due to the increased working from home due to the COVID-19 pandemic, the possibilities for cyberslacking have increased. In the long run, such behavior could prove harmful to both workers and employers, and employers should educate their workers about the possible consequences of using smartphones during working hours from different perspectives. Such could be done, for instance, by creating guidelines informed by the central situations we present in our results.

Limitations and Future Research

It must be acknowledged that our study has several limitations. First, we focused solely on techno-distress, omitting the positive manifestation of technostress. As techno-eustress is a part of the holistic technostress process, this could be something to study in the future, as research exploring positive stress in personal IT use is scarce. Second, we relied on self-reported data, meaning the interviewees had to recall past experiences concerning their smartphone use. Due to this, memory bias may be present. Although we took precautions to mitigate such challenges, there are always possible inaccuracies when self-reporting and recalling past events. Moreover, the self-reported nature of the data introduces the potential for social desirability bias, where participants may provide responses they perceive as more acceptable or favorable. To mitigate the limitations associated with self-reporting, participants were given ample time to reflect on their responses, and they were explicitly informed that there were no right or wrong answers, as the primary focus was on understanding their personal experiences and stories. Third, although qualitative methods were deemed valid for the research context and objectives, they inherently limit the generalizability of the findings. Nonetheless, the primary aim was to offer

a deep and nuanced understanding of the phenomena under study by exploring detailed narratives of the study participants' experiences. Future research could expand on these insights by employing alternative methods to generate more generalizable results. Fourth, the assessed demographic factors also reflect limitations, as our interviewees were mainly young adults from similar cultural and educational backgrounds. Fifth, as the second data collection phase of the study (20 interviews) was conducted during the COVID-19 pandemic, other limitations may have arisen. For example, some interviewees thought the pandemic had increased their smartphone use (e.g., due to spending more time at home). Sixth, the services, applications, and sites used by our interviewees represent a limiting factor. Due to our focus on digital content feeds, our study only included some types of personal smartphone use (e.g., playing games or using online banking were omitted). We may have missed exciting and important narratives regarding smartphone use that could have been relevant to our research goals. This, however, could be an exciting avenue for future research.

Our study presents multiple possibilities for future research. First, future research could explore the positive aspects of technostress within contexts similar to those examined in this study. While the concept of techno-eustress has gained increasing attention, there remains limited research on its occurrence in personal and voluntary IT use settings (Tarafdar et al., 2024). Future studies could build upon our approach to examining gratifications and technostress by investigating how the gratifications sought and obtained through IT use are linked to positive manifestations of technostress. For example, prior research has shown that technostress spilling over from work to home can influence partnership satisfaction, either positively or negatively (Benlian, 2020). Expanding on this, future studies could examine whether technostress arising from activities such as social media use might also have positive effects and how such outcomes influence partnership satisfaction. Second, it is important to highlight how the smartphone use loop and its interplay with technostress is unique to each user, since stress is a subjective phenomenon (Lazarus & Folkman, 1984). This indicates that more research must be conducted to understand the relations between 1) different personalities and technostress and 2) different situational factors and technostress. It may also prove interesting to extensively address how technostress can affect the smartphone use loop. Third, with regard to the uses and gratifications theory, one of the leading suggestions is that people are active when choosing media to consume (Katz et al., 1974). However, since many of the feeds are personalized by algorithms, it could be claimed that the active aspect of the uses and gratifications theory is something to reconsider in the future. Previously, it has been suggested that how algorithmic recommendation is perceived varies between individuals, which could affect how services utilizing such are used (Min, 2019). In accordance with this, it could be argued that people's attitudes toward personalized services and their use could be the active aspect of media consumption in this context, even if algorithms guide the consumption event itself to some degree, which could be an interesting future research avenue. In a similar vein, habits could be studied as a part of the equation. Fourth, further research is needed to clarify how specific dimensions of smartphone use are explicitly linked to particular gratifications and technostressors. We propose that this exploration could benefit from a quantitative approach, investigating these associations in greater depth. In this study, we presented examples of potential relationships between dimensions of smartphone use, gratifications sought and obtained, and technostress. These relationships could serve as a basis for developing theoretical models that can be tested quantitatively to confirm their existence and, if validated, to assess

the strength of the associations between dimensions of use, gratifications, stressors, and strains. Fifth, gratifications and technostress could be examined by distinguishing between process gratifications and content gratifications, which refer to the gratifications derived from engaging with the media itself and those obtained from the content delivered by the media, respectively (Cutler & Danowski, 1980). This approach could offer deeper insights into the role of various types of content and activities in the technostress process.

CONCLUSION

In this paper, we explore technostress caused by browsing digital content feeds on smartphones. We identify five dimensions of smartphone use (instant, repeated, continuous, personalized, and versatile), which reflect how smartphones are used in the context. Subsequently, we discuss the gratifications sought and obtained (hedonic, social, and utilitarian), which reflect why smartphones are used. We introduce the concept of smartphone use loop, bringing forth new knowledge by integrating both what is sought and obtained from the use (gratifications) and how the smartphone is used (dimensions of smartphone use). We assess the interplay between the smartphone use loop and technostress, contributing to the technostress literature by linking the different dimensions of use and the gratifications with technostressors and strains/outcomes. As a practical implication, service providers could use our findings when designing digital content feeds to minimize the likelihood of user behavior that could result in technostress manifesting as, for instance, discontinued use.

IMPLICATIONS FOR RESEARCH

We contribute to research especially in the area of technostress by delineating the hows and whys of browsing digital content on smartphones, and their associations with emerging technostressors and the associated strains/outcomes. Thus, we underline how the technostress process is influenced by users' underlying motivations, their potential fulfillment, and the nature of their actions, thus highlighting both cognitive and behavioral antecedents for technostress. By incorporating the concepts of gratifications, dimensions of use, technostress, smartphones, and digital content feeds, we offer a multidisciplinary approach for holistically explaining technostress emergence. The conceptualization of the smartphone use loop and the dimensions of use presents an opportunity for researchers to develop refined frameworks for analyzing user behavior associated with technostress. We find it crucial to further understand why individuals, especially while engaging in voluntary and leisure-oriented IT use, end up in situations that elicit technostress. Furthermore, investigating how different dimensions contribute to various technostressors can provide insights into nuanced aspects of user experiences and inform the studies aimed at mitigating technostress.

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INCREASING ENERGY AWARENESS THROUGH EFFECTIVE ADVERTISING MESSAGES – A NEUROPHYSIOLOGICAL APPROACH TO ENGAGEMENT STUDY

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Abstract: *The article presents the application of neurophysiological measurements when evaluating the effectiveness of advertising messages aimed at increasing energy awareness. The study focused on two commercials promoting pro-ecological behaviors. The level of audience engagement was analyzed using the engagement index (EI), which was determined based on EEG studies. The results suggest that appropriately designed scenes (surprising, humorous situations, longer rather than shorter ones, etc.) could increase engagement. Continuous upward trend in engagement, confirmed by the time analysis of EI, validated the alignment of the advertisement design with models of advertising impact on the audience. The study demonstrated that EEG is an effective tool for assessing audience reactions to advertisements, which can lead to more effective advertising campaigns promoting pro-ecological behaviors.*

Keywords: *energy awareness, social advertising, engagement, neurophysiological measurement, EEG (Electroencephalography)*

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INTRODUCTION

Energy constitutes a critical factor in sustainable development. It is linked to nearly all (economic, social, and environmental) dimensions of this development. It significantly influences the achievement of sustainable development goals, from eliminating poverty and hunger worldwide through providing healthcare, education, and industrial development to combating climate change and its impacts (Munasinghe, 2004; Stankevičienė & Borisova, 2022; UN General Assembly, 2015). One of the Sustainable Development Goals (SDGs) directly addresses energy issues. This goal (SDG 7) provides for access to affordable, reliable, sustainable, and modern energy for all (McCollum et al., 2017). For this to be achieved, however, large-scale efforts must be undertaken to ensure an effective energy transition, particularly towards renewable energy sources. Here, another important task relates to reductions in energy waste, as they positively impact the natural environment (e.g., combating global warming). Finally, improving energy efficiency saves money for both individual households and the economy. The potential for changes in this area is evident across all sectors of the economy, along with a wide range of possible actions (Creutzig et al., 2015; Cullen et al., 2011; Edenhofer, 2015; Moriarty & Honnery, 2019). High energy efficiency comprises many factors that can be grouped into two overarching categories. The first concerns issues related to broadly understood technology, while the second pertains to the energy awareness of users (consumer behavior).

Technological aspects of improving energy efficiency focus on enhancements within available technology. Some solutions are well-known and proven through years of application, while others are novel, innovative, and less familiar. This pertains to technologies available on both the supply and demand sides. In the first case, these are technical solutions (as well as management procedures) implemented by network operators, energy distributors, or manufacturers of consumer products. The second case includes all actions and technical devices that can be implemented on the customer (consumer) side (Y. Chen & Liu, 2021; National Academy of Engineering, 2009). Examples of solutions that increase energy efficiency include: building and using more efficient transmission and distribution systems (Melhem, 2013; National Academy of Engineering, 2009), converting surplus heat to electricity (Q. Chen et al., 2016; Energy & others, 2014), using renewable energy sources (Kolosok et al., 2021; Salameh, 2014; Streimikiene, 2022, 2024), using energy-efficient appliances (Stoffels & Vielhaber, 2016; Waris & Hameed, 2020) and many others. The energy efficiency assessment and consumption by various devices, buildings, systems, etc., is becoming increasingly reliable and more accessible. Multiple models (Bermeo-Ayerbe et al., 2022; Drobyazko et al., 2021; Mo & Zhao, 2021), standards, policies, recommendations, certificates, norms (Asdrubali & Desideri, 2019; *Energy Efficiency*, 2019; European Commission, 2020; Poveda-Orjuela et al., 2019; uit het Broek et al., 2020), etc., are being developed.

Issues related to the energy awareness of energy consumers are more critical and, at the same time, more accessible to assess. They concern every person using various energy-consuming devices daily, whether at home, work, school, traveling, or on vacation. It must be unequivocally stated that even the most advanced technology will not solve the problem of energy waste. Therefore, it becomes necessary to raise awareness and change the behavior of energy users to be more economical and environmentally friendly. People tend to take energy

for granted. Many are unaware that they can significantly influence energy consumption reduction. Even if some advocate for energy efficiency, they do not necessarily change their behaviors in this regard. As the International Energy Agency notes, the global improvement in energy efficiency is the slowest in 10 years (International Energy Agency, 2020). Hence, it is essential to intensify efforts to increase energy awareness. These efforts must be multifaceted, reach a broad audience, and be effective. Various approaches, often called energy efficiency interventions, are currently being used worldwide. The main assumptions of these interventions are based on several fundamental principles: people will change their behavior if they understand the problem, know what to do, or realize that it is in their best interest (Kollmuss & Agyeman, 2002; Ro et al., 2017).

Interventions are conducted on a micro-scale (households), a macro scale (policies, regulations), and a multi-level scale (both micro and macro combined). They are mainly focused on providing consumers with information, feedback, and specific actions that encourage energy savings (Jacobsen et al., 2012; McAndrew et al., 2021; Juhasz et al., 2023). The most commonly used intervention tools include information and education (training, workshops); financial mechanisms (tariffs, rewards) (Abrahamse et al., 2005; Ó Broin et al., 2015); visualizations of energy consumption and displaying selected feedback information on meters, displays, smartphones, tablets, etc. (Morganti et al., 2017; Murugesan et al., 2015; Schultz et al., 2015); using games and gamification to engage consumers in saving behaviors (Morganti et al., 2017); and energy audits and home retrofits (Ehrhardt-Martinez et al., 2010; Karlin et al., 2014; Lazowski et al., 2018). Interventions using feedback and specific encouraging actions are more costly and limited in terms of personnel. On the other hand, general informational activities can be directed to a broad audience. These are standard methods of raising energy awareness conducted by various governmental and international institutions, energy producers, and manufacturers of devices and other material goods. Informational messages are often delivered through social campaigns, video advertisements, computer games, posters, leaflets, websites, etc. Mass media, such as television, radio, the Internet, and the press, are disseminated. However, the effectiveness of both informational activities and feedback interventions can vary. Poorly prepared informational and feedback interventions may result in only minor and temporary changes in energy savings. After the intervention ends, a return to normal (previous) usage may occur (Bird & Legault, 2018).

The effectiveness of the informational message presented to users largely depends on its construction. It should attract attention, arouse interest, engage emotions, and be memorable. It should provide reliable, specific information delivered convincingly and attractively. Furthermore, it should be tailored to and reach a particular target audience. Repetitive information presentation schemes are sometimes used, but they only sometimes prove effective.

Moreover, frequently repeated solutions become commonplace and fail to meet their original objectives. Good practices are often not applied when designing informational (advertising) messages. For example, website information architecture is usually low, and overall usability discourages users from seeking information. In the case of video advertisements (often social), the storyline can be irritating, and the advertising slogan fails to evoke any emotions, interest, or engagement and needs to be more memorable and effective. While more extensive advertising campaigns typically involve a multi-level message design process that includes surveying potential audience opinions, various methods and techniques

for research and testing are used depending on the form of the informational message. These typically boil down to declarative forms (surveys, interviews), where the evaluation is verbally communicated. However, such studies still need to answer emerging emotions, perceptions, attention focus, and other factors. These factors can be crucial when analyzing the reception of designed messages, which are the primary information form. Expecting changes in human behavior and building energy awareness is more accessible with practical information.

The article aims to present the potential of using neurophysiological measurements to assess engagement in the reception of advertising messages intended to increase energy awareness. The essence of the studies described is to demonstrate that using brain electrical activity measurements (EEG) and determining an engagement index based on them can provide added value in research on the applicability of advertising impact models on the recipient and the design of advertising messages. Engaging consumers in advertising messages is desirable regardless of the adopted model. However, it is difficult to measure and assess, partly due to the emotional nature of this phenomenon and the dynamic nature of advertising messages. The presented research results show that neurophysiological studies offer high accuracy in assessing the level of engagement (e.g., at the level of film frames or thematic scenes). Such a methodological approach is also considered more objective than other declarative assessment methods. This may be significant in evaluating the effectiveness of advertising messages, which in practice is supported by models that assess advertising's impact on the recipient. Ultimately, this allows for a better understanding of how advertising influences consumer behavior and decisions. The subject of the study comprises two natural advertising spots (videos) aimed at promoting pro-ecological behaviors. The research method involves measuring the brain's electrical activity (EEG), based on which an engagement index was determined. It analyzes the level of engagement allowed to verify the effectiveness of the advertising messages and relates the obtained results to the defined phases in advertising impact models.

The article consists of five parts. Section 2 discusses the concept of advertising impact models on audiences. Section 3 describes the research experiment, the group of subjects, and the methods, algorithms, and analyses used. Section 4 presents the research results, and the following section discusses them. The final part of the article contains concluding remarks and practical implications of the research.

ADVERTISING IMPACT MODELS ON AUDIENCES

Messages aimed at increasing energy awareness often take the form of videos or are purely informational. In the first case, these are typically social advertisements and educational videos, while in the latter case, they consist of various leaflets, posters, internet information, press articles, etc. The design of informational or advertising messages varies depending on their form. The primary goal is to achieve maximum effectiveness. The result is to generate consumer interest and convince them to purchase a product or, for example, change their habits (social advertisements). Therefore, many methodological approaches have been developed to describe the impact of advertising messages on audiences. The most well-known advertising impact models include AIDA and models based on this framework:

AIDAS (S-Satisfaction), AIDAL (L-Loyalty), and AIDCAS (C-Conviction, L-Loyalty). Other well-known models include DAGMAR, DIPADA, FCB, Lavidge-Steiner, ACALTA, EKB, and Ray's (Chakravarty & Sarma, 2022).

The choice of a marketing impact model determines the type and conditions of building the message. Often, the model specifies the technology used for implementation, the type of advertisement, or the type of media. The fundamental idea of any advertising impact model is to attract attention, generate interest, stimulate desire, and prompt specific action, such as purchasing products or changing habits (Koziara, 2017). The most well-known advertising impact models are presented in Table 1. They differ in the defined phases of the process or the evocation of specific affective and cognitive states in the audience.

Table 1. Selected Advertising Impact Models on Audiences.

Model Name	Phases	Literature
AIDA	Attention, Interest, Desire, Action.	(Ullal & Hawaldar, 2018) (Dharti Narwani, 2023) (Universitas Bakrie, Jakarta - Indonesia & Sukma Wijaya, 2012)
DAGMAR (**D**efining **A**dvertising **G**oals for **M**easured **A**dvertising **R**esults)	Unawareness, Awareness, Comprehension, Conviction, Action.	(X. Chen, 2023) (Egede, 2013)
DIPADA	Definition, Identification, Proof, Acceptance, Desire, Action	(Furnham, 2008)
FCB	The FCB grid takes into account four factors: Thinking, Feeling, as well as High and Low involvement.	(Vaughn, 1980)
Lavidge-Steiner	Awareness, Knowledge, Liking, Preference, Conviction, Purchase.	(Lavidge & Steiner, 1961)
ACALTA	Awareness, Comprehension, Attitude, Legitimation, Trial, Adoption.	(Chakravarty & Sarma, 2022)
EKB (**E**ngel-**K**ollat-**B**lackwell)	Need recognition, Information search, Evaluation of alternatives, Purchase decision, Outcome analysis.	(Longart et al., 2016) (Srivastava et al., 2021)

Analyzing the various models, it is evident that an essential role of the advertising message is to build an emotional (Rejer et al., 2024) and intellectual bond and engage the audience in purchasing a product or adopting or changing habits (Kovacic, 2014). The stronger the bond created, the more the advertised goods will be entrenched in the audience's consciousness (Otamendi & Sutil Martín, 2020).

For the models listed in Table 1 (regardless of the number and type of stages), three phases of the advertising message can be distinguished: the cognitive, affective, and conative phases (Barry & Howard, 1990). The cognitive phase is the stage of awareness where the advertising message is entrenched in the consumer's consciousness. The clarity of the brand, products, and promoted habits is tested by comparing them with other advertisements. If the respondent identifies the advertisement among competing messages, it indicates strong retention in the audience's consciousness. In the affective phase, the attitude towards the

advertised item is shaped. Research in this phase focuses on determining how the advertising message translates into decisions made. The conative phase aims to prompt the audience to take action that aligns with the advertisement's message (such as purchasing a product, using a service, or changing habits). Research in the conative phase focuses on the audience's behaviors after viewing the advertisement (Barry & Howard, 1990).

The models in Table 1 structurally describe methods for building positive relationships with the audience. Viewer engagement in advertising content interacts with the message and the audience. The message encourages action, such as following the advertised product online or on social media, using loyalty programs, imitating behaviors, and developing certain habits. This approach initiates building loyalty and trust towards products, services, etc. In practical terms, this can translate into repeat purchases or specific behaviors.

The fundamental goal of social advertising related to energy conservation is to convey information and evoke a specific emotional response. This can prompt the audience to take action in line with the message (Kotler & Lee, 2008). Advertisements that elicit emotions and provoke reflection are more effective in promoting changes in the attitudes and behaviors of the audience. Numerous studies confirm that viewer engagement in receiving the advertisement significantly impacts its effectiveness. In particular, a high level of engagement leads to deeper processing of the advertisement content (often subconsciously), enhancing understanding and retention of the message (Heath, 2001). Various studies have also shown that advertisements with high viewer engagement are more persuasive and influential (Akarsu & Serdar, 2023; Kim et al., 2017; Borawska et al., 2023). Increasing viewer engagement, especially in the early phases of impact models, can be achieved using techniques such as storytelling, well-known or engaging actors, or introducing interactivity (Edson Escalas, 2004). Advertisements that draw the audience into the storyline and action of the message at the interest-evoking stage have a higher chance of effective communication (Green & Brock, 2000). Therefore, designing advertisements with the highest possible level of engagement in the initial phases of impact models seems crucial to achieving the intended goals. This is practically independent of the adopted model (AIDA, DAGMAR, FCB, Lavidge-Steiner, etc.).

A critical issue is the method of studying or assessing engagement. Generally, three approaches can be distinguished: self-assessment questionnaires, behavioral measurement during tasks, and physiological measurement (Rejer et al., 2024). Each has its advantages and limitations. Self-assessment questionnaires are simple to conduct and analyze. They provide information about subjective feelings and opinions but can be distorted by subjective biases and are susceptible to manipulation (conscious or unconscious). Behavioral measurement is more objective than questionnaires and allows for the observation of behaviors in real-time. It requires specialized equipment, and data analysis is more complex and time-consuming. Physiological measurement has several significant advantages. It enables an understanding of emotional and cognitive reactions to advertisements. Since the measurement occurs at the level of changes in the human nervous system, it is considered the most objective. It records even the most minor physiological reactions a person cannot control. However, such studies require specialized equipment, software, and expert knowledge (Giombi et al., 2022).

Physiological measurement (EEG) was used to study engagement in social advertisements to increase energy conservation awareness. The results will allow for a precise analysis of consumer reactions to these advertisements. Achieving greater

engagement in the reception of the advertising message increases the chances of a lasting change in attitudes and the campaign's effectiveness. This is particularly true for complex advertising messages and products that require greater involvement in the decision-making process. Therefore, consumer engagement in the reception of the advertisement significantly impacts the effectiveness of advertising impact models.

MATERIALS AND METHODS

Participants

In the study, 30 individuals participated, out of which data from 29 respondents (14 women and 15 men) were included in the analysis. The measurements from one person were excluded due to technical issues in signal registration (poor quality of EEG signals). The participants were between 19 and 51 years old, with an average age of 29.38 years and a standard deviation of SD=10.67. One participant was left-handed, while the others were right-handed. The study included both students and working individuals. All participants were healthy and voluntarily took part in the study. They all signed consent forms to participate in the experiment and have their data processed for research purposes. Participants were informed about the study procedure (without revealing specific details about the experiment's content) and the measurement equipment used. The research experiment used the principles outlined in the Declaration of Helsinki (2013 version) (World Medical Association, 2013). The Bioethics Committees reported to and approved the study at the Regional Chamber of Physicians in Szczecin.

Research Protocol and Stimuli

The research protocol included 12 advertisements, one film, and additional significant screens for physiological measurement. All participants were shown a 30-minute documentary film interrupted by two commercial breaks. Each break contained six advertisements, both commercial and social. Each ten advertisement was 30 seconds long, while the two lasted 60 seconds each. The structure of the research protocol is presented in Figure 1.

EEG baseline	Film (part I)	Advertising block (no. 1)	Film (part II)	**Advertising block (no. 2)**	Film (part III)
SCREENS	VIDEO	AD1 ÷ AD6	VIDEO	**AD1 ÷ AD6**	VIDEO

Figure 1. Research protocol used in the experiment.

The advertisements analyzed in the study were placed in the second commercial break, each lasting 30 seconds. Both ads had a social message related to the necessity of saving electricity and developing good habits.

First Advertisement (referred to as Ad1):

- Advertiser: Energa (*Energa - Po Prostu Włącz*, 2012).
- Objective: This ad aimed to increase awareness about the efficient use of electricity and encourage potential customers to take advantage of Energa's offerings. The company promotes itself as the most eco-friendly energy provider in Poland. The advertisement emphasizes that saving energy involves simple tasks like turning off unnecessary lights, televisions, or computers. The main characters in this spot are animals: a canary, a dog, and a cat. In various scenes, these animals turn off power sources.

Second Advertisement (referred to as Ad2):

- Advertiser: Polish Ministry of Environment (*Wyłączamy Prąd, Włączamy Oszczędzanie*, 2012).
- Objective: This ad was part of an educational campaign on energy saving. Its goal was to raise awareness and rationally shape attitudes and habits about using electrical and thermal energy. The actors in this ad are a couple (a woman and a man) who discuss the linguistic and emotional aspects of turning power on and off.

To analyze the advertisements, both were divided into one-second frames and thematic scenes. The first and second advertisements were split into five scenes each. These scenes are briefly labeled as S1 (scene 1), S2 (scene 2), etc.

Scenes of Ad1 (with seconds in parentheses indicating the duration of each scene):

- S1 – A man and a woman walking around the apartment (0÷2; 9; 20);
- S2 – A canary flying out of its cage, sitting on the TV remote, and turning off the TV with its beak (3÷8);
- S3 – A dog lying on the couch, looking at the overhead light, then jumping onto a cabinet and turning off the light with its paw (10÷19);
- S4 – A cat looking at an open laptop, jumping onto the table, and closing the laptop; additionally, the narrator's voice informs that the animals are setting an example of saving energy and that everyone can save energy (21÷28);
- S5 – The energy provider's logo with a voice-over encouraging viewers to take advantage of their offer (29÷30).

Scenes of Ad2:

- S1 – A couple (woman and man) cuddling in bed at night (0÷3);
- S2 – The woman tells the man he should have turned off the TV, and the man points out that it should be said "turned off" instead of "switched off," leading to a discussion about the correct terminology (4÷17);
- S3 – The man turning off power-consuming devices, with the narrator's voice in the background stating the Ministry of Environment's position that it's not about what you turn off, but about what you save (18÷23);
- S4 – A screen with a light switch and the text and voice message of the advertisement "Turn off the power, turn on the savings" (24÷27);
- S5 – The man returning to bed (28÷30).

At the beginning of the measurement procedure, graphic stimuli were displayed on the computer screen to focus attention and establish a reference point (baseline). The neurophysiological reactions of the respondents were determined based on the brain activity

signals obtained during this phase. Subsequently, the process of displaying stimuli, which were the advertising spots, began.

Research Apparatus

The measurement of brain electrical activity was conducted using a portable 8-channel g.Nautilus system from g.tec. The wet measurement electrodes were positioned according to the international 10-20 standard at the following locations: Fp1, Fp2, F3, F7, Fz, F4, F8, and Cz. The ground (GND) electrode was placed on the surface of the head, and the reference electrode was attached to the left earlobe (ear clip). To place the electrodes, g.GAMMAcap^2 caps in two sizes (medium and large) were used. Before starting the measurement process, the impedance at the electrode-skin interface was checked, maintaining an upper limit of 10 kΩ. The brain activity was recorded at a frequency of 500 Hz. Noise level: < 10.6 μV RMS between 1 and 30 Hz.

A multi-step procedure was applied to preprocess the EEG signal, consisting of several stages: data import (.hdf5 format), filtering, electrode localization, event import, checking for bad channels and possibly their interpolation, removing eye artifacts, re-referencing the data, dividing the signal into epochs, removing epochs containing data with remaining artifacts (Piwowarski et al., 2021). A fifth-order Butterworth filter [2-30 Hz] was used to filter out frequency ranges irrelevant to the study, allowing for the removal of high-frequency noise, e.g., muscle artifacts (above 30 Hz) and the elimination of slow drifts (below 2 Hz). The electrode localization step involved loading and verifying channels' correct placement and order according to the established locations during the measurement. A procedure was implemented to extract events from the recorded signal to import an event definition file and set processing parameters. Since the entire EEG signal was processed, extracting specific segments, i.e., individual advertisements, was necessary. Time markers (events) were used for this purpose to identify the start and end of each ad (videos in .mp4 format), as well as other important moments in the study (e.g., technical issues reported by the researcher during the measurements or behaviors of the subjects). A complete measurement environment was developed, which included preparing the research project (defining stimuli, primarily advertisements), displaying them to the subjects, and recording events (a separate .xls file was created for each subject). This was done by a team of researchers working within the cognitive neuroscience laboratory. The measurement and recording of the EEG signal began after pressing the start button, after which the stimuli (advertisements) automatically appeared on the screen. Pressing the start button generated the first event, and its timestamp was recorded with an accuracy of 1 millisecond. In both analyses, each advertisement's start caused subsequent events, and their timestamps were recorded in the file. The recorded EEG signal (containing time markers) was synchronized with the events saved in the file using a dedicated function in the EEGLAB toolbox. The next step involved actions aimed at identifying the wrong channels. Bad channels can occur, for example, due to poor electrode contact with the scalp, resulting in a low signal-to-noise ratio. In the described study, the main focus was on analyzing the correlation of signals from adjacent channels, flat signals, and the level of high-frequency noise. Two bad channels were identified in total, each in two different subjects (Fz and F4). The probable cause was either an insufficient amount of conductive gel applied to the measurement electrodes or its partial leakage during the EEG

measurement. After additional visual identification of bad channels for the entire recorded signal, it was decided to remove these two channels (for the two subjects). The removed channels were interpolated based on other valid channels. The interpolation was performed following the ICA procedure described below.

Various methods were applied for artifact removal. In the first step, ocular artifacts were identified and subsequently removed. For this purpose, Independent Component Analysis (ICA) and the Infomax algorithm were applied (Makeig et al., 1996). The use of ICA allowed for extracting independent components of signal sources, including artifacts of ocular origin. Due to the relatively small number of measurement electrodes (which translates into a similar number of extracted components), it was decided to remove only one component – the component corresponding to ocular-origin disturbances. Ocular artifacts are relatively easy to identify, and ICA analysis effectively identifies this noise source (even with a small number of applied electrodes). The ICA procedure was conducted in the EEGLAB toolbox and had a semi-automatic character. Independent components were extracted automatically using the ICLabel classifier. The decision to remove components was made after a visual analysis of the obtained components using topographic head maps. Other components were not removed due to the higher likelihood of removing brain activity signals in the remaining components.

The next stage of the preprocessing procedure involved re-referencing the EEG data. During signal recording, the data were registered with reference to the electrode placed on the left earlobe, a commonly used practice due to the good signal quality and noise suppression obtained. However, such referencing is not the most optimal solution at the data analysis and interpretation stage. It is not recommended to use only one earlobe, as this approach is unbalanced and tends to lower activity in the homologous hemisphere of the considered earlobe. Therefore, a re-referencing process was applied, using the linked earlobes as the reference.

The final stage of the preprocessing procedure involved removing other artifacts. To eliminate other artifacts, the continuous EEG signal was divided into epochs (1-second time windows). The criteria for marking artifacts in the defined epochs were signal amplitude exceeding ±75μV and a trend slope between epochs exceeding ±10μV/s, with R-squared=0.3. Epochs identified with artifacts were removed. The cleaned signal was then subjected to analysis. EEG signal processing was performed using Matlab, EEGLAB, FieldTrip toolboxes, and custom scripts.

Analysis of Measurement Data

The primary measure derived from the processed EEG signal and subjected to analysis was GFP (Global Field Power). The GFP measure corresponds to the spatial standard deviation of the average EEG amplitude (at each time point) from all eight measurement electrodes simultaneously (Skrandies, 1990). To more precisely determine the frequency band ranges for all study participants, the Individual Alpha Frequency (IAF) was calculated (Corcoran et al., 2018). Based on the IAF, the alpha, beta, and theta bands were defined in the study. This was done using the formula IAF ± x, where x is the number determining the start and end of the band in Hz. The alpha range was defined as [IAF-2 Hz ÷ IAF+2 Hz], the beta range as [IAF+2 Hz ÷ IAF+14 Hz], and the theta range as [IAF-6 Hz ÷ IAF-2 Hz]. The extraction of

bands was carried out using the Discrete Fourier Transform (DFT) and bandpass filtering. The GFP value was calculated using the following formula:

$$GFP = \frac{1}{N}\sum_{i=1}^{N} x_{\vartheta_i}(t)^2, \tag{1}$$

where: ϑ is the considered EEG band,
N is the number of electrodes,
i is the electrode index,
x represents the EEG sample at a time (t), filtered within the related EEG band (ϑ) and for the specific channel i.

Sampling was performed in frames of 51 samples in length. To calculate the GFP, the middle value of the frame (EEG sample) was taken, and then the frame was shifted by 1. This procedure was repeated for the subsequent frames created in this way.

Using the GFP measure, an Engagement Index (EI) was calculated, which was based on the recorded changes in brain activity in the beta, alpha, and theta bands, according to the following formula (Cartocci et al., 2019):

$$EI = \frac{GFP\beta}{GFP\alpha + GFP\theta}. \tag{2}$$

The methodological assumptions of this index are based on the premise that an increase in beta activity is associated with an increase in alertness and engagement in a cognitive task. Conversely, increased alpha and/or theta frequency activity reflects decreased alertness and engagement (Cartocci et al., 2019; Coelli et al., 2015; Lelis-Torres et al., 2017; Pope et al., 1995).

The value of the EI index was normalized (z-score) for each time point of the advertisement (1 second) using the mean value and standard deviation of the EI values obtained for the baseline (the initial screen of the study) (Cartocci et al., 2019):

$$Normalized\ index\ (z-score) = \frac{index\ value - \ mean\ value\ (baseline)}{standard\ deviation\ (baseline)}. \tag{3}$$

Various methods were used for statistical analyses. The between-group differences were examined using the Student's t-test with Welch's correction, the non-parametric U Mann-Whitney test, the non-parametric Kruskal-Wallis test, and the Dunn-Bonferroni post-hoc test. Additionally, Pearson correlation and linear regression were applied.

RESULTS

The Engagement Index (EI) values determined from the EEG measurements were analyzed for consecutive time points (every 1 second) and the identified thematic scenes. This approach allowed for verifying the impact of both advertisements (Ad1, Ad2) on the audience in the context of the assumptions and defined phases of the various models (AIDA, DAGMAR, etc.). The analysis conducted with 1-second accuracy enabled the assessment of

how the level of engagement changed over time. The thematic scenes provided additional information about the effectiveness of the advertisement's script, including the storyline, actors, actions, and dialogues.

The distribution of aggregated EI values for the entire group of respondents for advertisement Ad1 is shown in Figure 2.

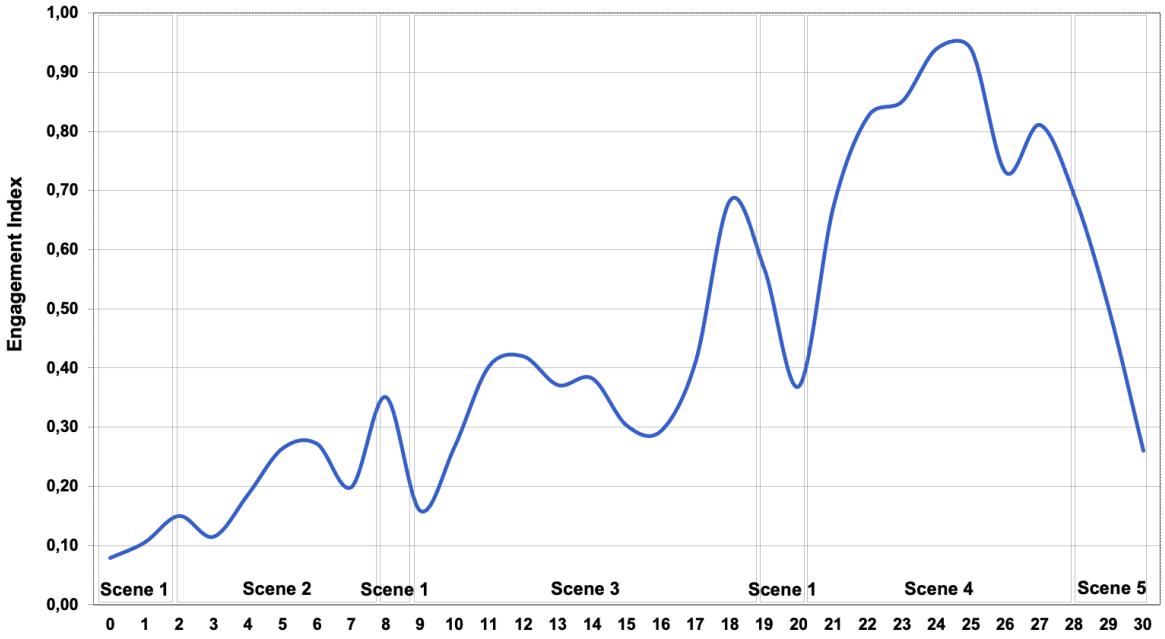

Figure 2. Engagement index (EI) values over time for advertisement Ad1.

The obtained EI results indicate a gradual increase in engagement levels, starting from an EI=0.079 at the beginning of the advertisement to a maximum value of EI=0.939 at the 24-second mark. Between these time points, local peaks in engagement can be observed (e.g., at 6s, 8s, 12s, 18s), followed by declines in EI values. After reaching the highest engagement level (24s), there was a sharp decline to an EI value of 0.260 in the last second of the advertisement. To better understand the reasons for changes in engagement during the ad, it is necessary to examine the thematic scenes closely. The highest EI values were achieved for scene S4, where the leading actor is a cat. This scene begins with a camera close-up of the cat (21s, EI=0.672) staring at something. The cat then runs towards the table, jumps on it (24s, EI=0.939), and closes the laptop (26÷27s, EI=0.731÷0.811). The second highest engagement is in scene S3, featuring a dog. The first peak of engagement in this scene occurs when the dog raises its head and stares at the ceiling lamp (12s, EI=0.419). The second, significantly higher peak of engagement in this scene happens when the dog jumps onto the cabinet and turns off the light with its paws (18÷19s, EI=0.683÷0.566). In scene S2, where a bird turns off the TV using a remote, an increase in EI value can also be observed (8s, EI=0.351). Compared to scenes S4 and S3, the engagement level is relatively small. The final scene of the advertisement (S5), containing the logo and information about the energy provider, is marked by a significant drop in engagement level compared to the preceding scene, indicating a general decline in interest in this part of the advertisement.

When analyzing the engagement index distribution over the second advertisement's duration (Ad2), significant differences can be observed compared to those in Ad1 (Figure 3).

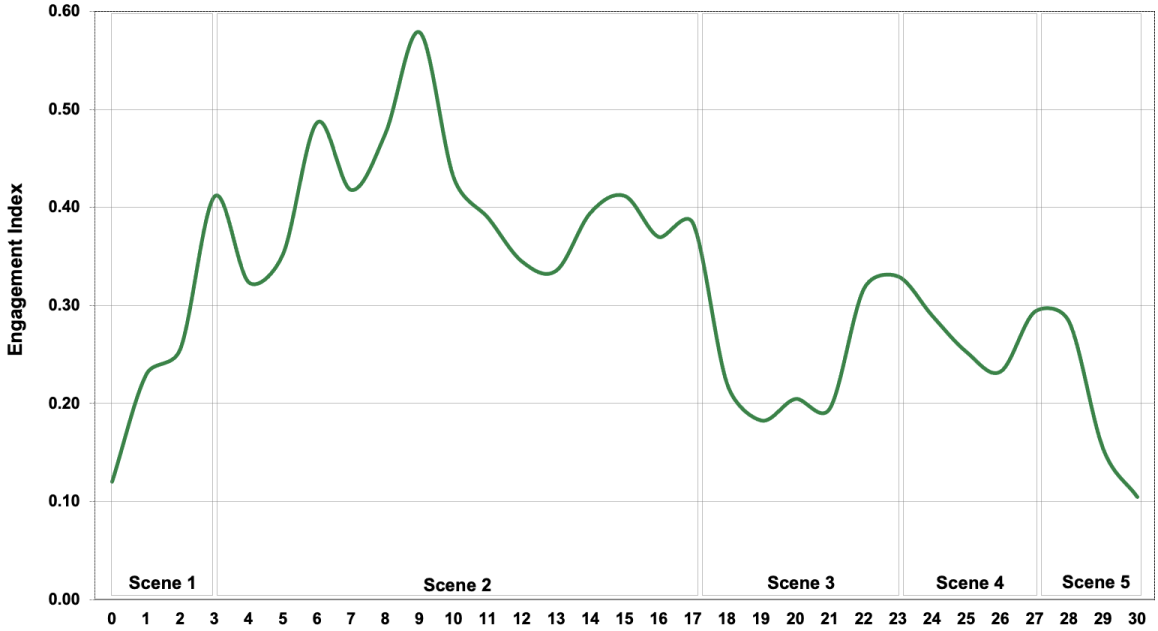

Figure 3. Engagement index (EI) values over time for advertisement Ad2.

From the beginning of this advertisement, the EI values increase dynamically, reaching the first peak at 3 seconds (EI=0.411), the second at 6 seconds (EI=0.487), and then the maximum for the entire clip at 9 seconds (EI=0.579). From this point, engagement levels decrease, noting small, local increases around 15÷17 seconds (EI=0.412÷0.384), 22-23 seconds (EI=0.317÷0.329), and at 27 seconds (EI=0.294). In the context of increasing engagement, significant scenes are S1 and part of scene S2. In the 3-second scene S1, a woman and a man lie in bed, cuddling each other. This segment triggers the rise in engagement, which continues through the first 6 seconds of scene S2. During this period, a conversation (a minor argument) occurs about turning off the TV (the woman) and switching off the TV (the man). The prolonged discussion causes a decrease in EI values. In scene S3, the man turns off electrical devices while the narrator's voice delivers a message from the Ministry of Environment. Turning off the radiator at the end of this scene causes a slight increase in engagement. The end of scene S4 (a screen with a message about saving power) and the beginning of S5 result in a temporary rise in EI values, after which the last seconds of S5 lead to a decline.

Besides analyzing the engagement levels at individual time points (every 1 second), a generalization for the entire advertisement can be made. This will help determine which advertisement is more engaging overall. The average EI values calculated for Ad1 and Ad2 are presented in Figure 4.

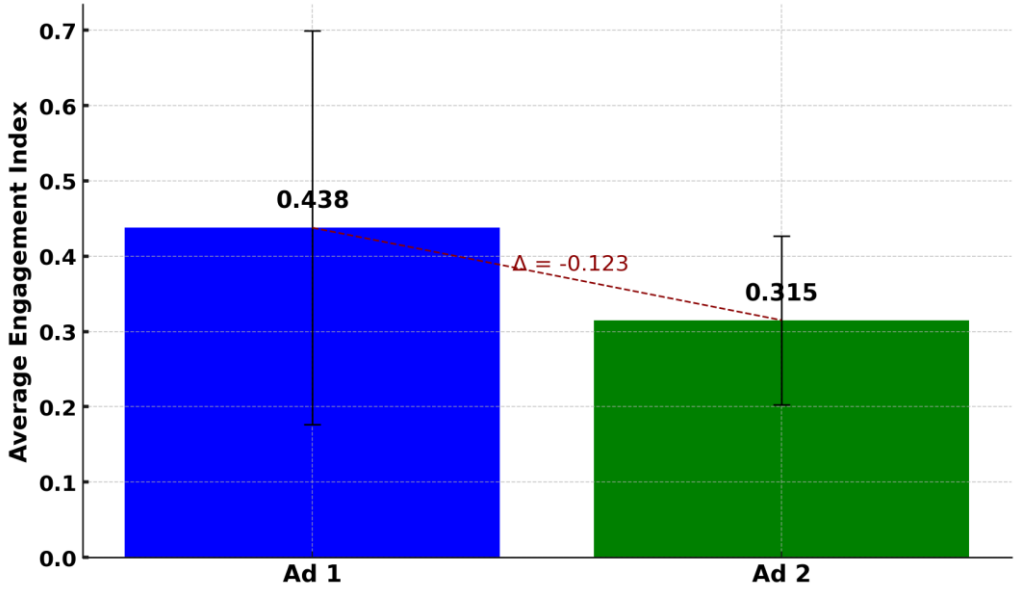

Figure 4. Comparison of average Engagement Index (EI) values for Ad1 and Ad2.

The average Engagement Index (EI) value for advertisement Ad1 is EI=0.438, while for advertisement Ad2 it is EI=0.315. This indicates that Ad1 generates a higher average engagement than Ad2. The difference between these averages is -0.123 (the average EI for Ad2 is lower than the average EI for Ad1 by this amount). The error bars, showing the standard deviation for each advertisement, differ significantly. For Ad1, the standard deviation is higher (SD=0.261) than for Ad2 (SD=0.112), suggesting more significant variability in engagement.

Two tests were used to test the significance of the differences between the average EI values for both advertisements: the Student's t-test with Welch's correction and the non-parametric U Mann-Whitney test. This approach was taken because the data distribution (Shapiro-Wilk test) for one of the groups (Ad1) was not typical: Ad1 (p=0.022), Ad2 (p=0.982). Levene's test (p=0.0005) indicated that the assumption of homogeneity of variances was not met. The result of the Student's t-test (with Welch's correction) suggests that the difference in average engagement index values between Ad1 and Ad2 is statistically significant t(60)=2.40, p=0.019. The non-parametric U Mann-Whitney test did not significantly differ between the EI values for Ad1 (Med=0.371) and Ad2 (Med=0.323), U=583.0, p=0.151. Considering the results of both tests, it can be concluded that the differences between the average EI values for both advertisements are noticeable. However, verifying statistical significance would require a more extensive data set.

The variability in engagement, visible in the standard deviations, may indicate different audience reactions to the advertisements at various intervals. Therefore, further analyses were conducted at the level of the identified scenes in both advertisements (Figure 5).

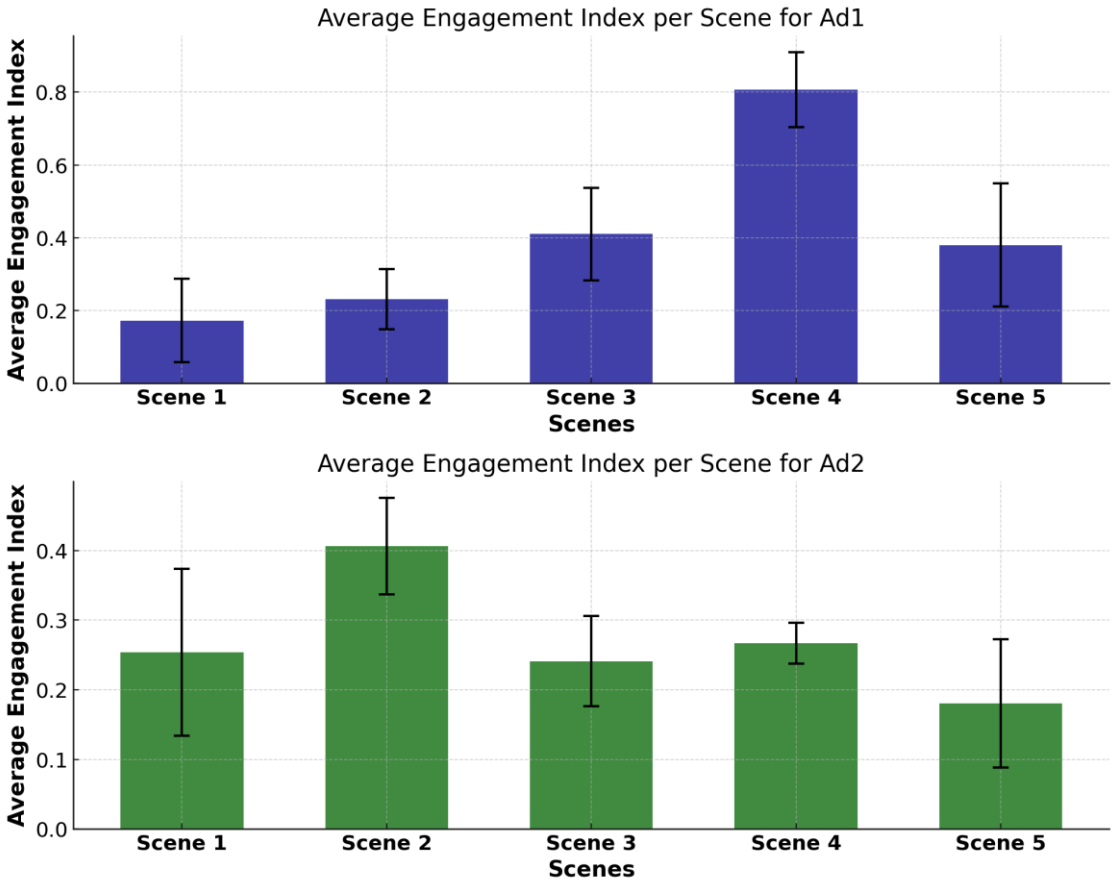

Figure 5. Comparison of average Engagement Index for different scenes in video advertisements: Ad1 and Ad2.

Analyzing the average EI values for the scenes in Ad1 suggests that the initial scenes did not elicit high engagement: S1 (EI=0.173) and S2 (EI=0.231). A more significant increase in engagement is observed for S3 (EI=0.410), with the highest engagement occurring in S4 (EI=0.807). Engagement decreases in S5 (EI=0.380) but remains relatively high. Therefore, scenes S3 and S4 proved particularly effective in increasing engagement.

For Ad2, scene S1 (EI=0.254) generates relatively high engagement, indicating a reasonably practical capture of viewer attention at the beginning of the ad. The significant standard deviation for this scene (SD=0.120) indicates considerable participant engagement variability. An apparent increase in engagement is seen in S2 (EI=0.407), suggesting that the content in this scene was more exciting and engaging. Subsequent scenes show a decline in engagement: S3 (EI=0.241) and S4 (EI=0.267), with the lowest value in S5 (EI=0.180).

The next step was to check whether the differences in average EI between the scenes could be considered statistically significant. Since the EI values for all scenes did not follow a normal distribution, the non-parametric Kruskal-Wallis test was used. The lack of normal distribution for Ad1 was observed in scenes S2 ($p=0.029$) and S4 ($p=0.018$) and for Ad2 in scene S1 ($p=0.035$). The Kruskal-Wallis test showed statistically significant differences in engagement levels between scenes for both Ad1 ($H(4)=22.34$, $p<0.001$) and Ad2

(H(4)=14.67, p=0.005). The Dunn-Bonferroni post-hoc test identified which scenes these differences occur between (Table 2).

Table 2. Results of Dunn-Bonferroni tests for engagement levels in advertisement Ad1 and Ad2.

Advertisement (Ad1)			Advertisement (Ad2)		
Scenes		p-value	Scenes		p-value
Scene 1	Scene 3	0.001	Scene 1	Scene 2	0.032
Scene 1	Scene 4	0.000	Scene 2	Scene 3	0.046
Scene 1	Scene 5	0.035	Scene 2	Scene 4	0.022
Scene 2	Scene 3	0.003	Scene 2	Scene 5	0.018
Scene 2	Scene 4	0.000			
Scene 2	Scene 5	0.037			
Scene 3	Scene 4	0.000			
Scene 4	Scene 5	0.001			

The Dunn-Bonferroni test results for advertisement Ad1 showed statistically significant differences in viewer engagement levels between several pairs of scenes. Scenes S1 and S2, which exhibited the lowest average engagement index values, significantly differed from S3, S4, and S5. Similarly, scenes S2 and S4 compared to S5 and S3 and S4 showed significant differences.

For advertisement Ad2, the variation in EI levels between scenes was more minor. Scene S2 stood out, with statistically significant differences in engagement compared to the other scenes (S1, S3, S4, S5). This suggests that S2 contains elements that capture viewers' attention and engage them more. No significant differences were found between the other scene pairs.

Pearson's correlation was applied to examine the relationship between the duration of individual scenes and the level of engagement (EI) in viewing them (separately for Ad1 and Ad2) (Figure 6).

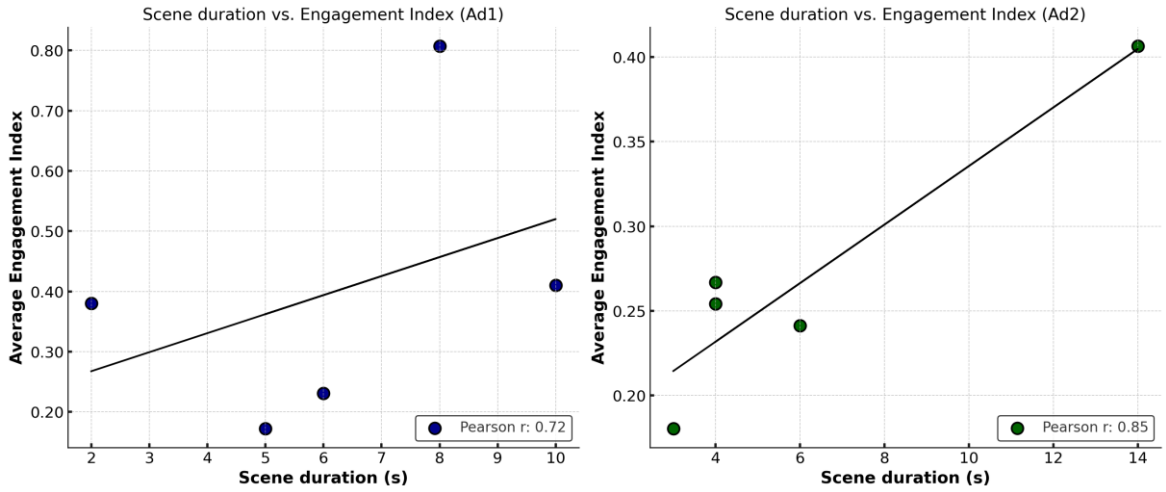

Figure 6. Correlation between scene duration and Engagement Index for advertisements Ad1 and Ad2.

For advertisement Ad1, there is a moderate positive correlation between scene duration and the average engagement index, r(3)=0.72, p=0.12. This suggests that more extended scenes in Ad1 are associated with higher engagement levels (EI), although this relationship is not statistically significant at the 0.05 level. For Ad2, an even stronger positive correlation was found between scene duration and engagement index, r(3)=0.85, p=0.03. This strong positive correlation indicates a statistically significant relationship between scene duration and engagement, suggesting that more extended scenes significantly increase viewer engagement.

Linear regression analysis was applied to investigate the relationship between the total duration of advertisements and viewer engagement. By interpreting the regression coefficients, we can better understand the impact of time on engagement. Identifying trends in EI values helps determine whether engagement increases or decreases as the advertisement progresses. Figure 7 shows the linear regression of the Engagement Index (EI) as a function of time for ads Ad1 and Ad2 (scatter plot and regression line).

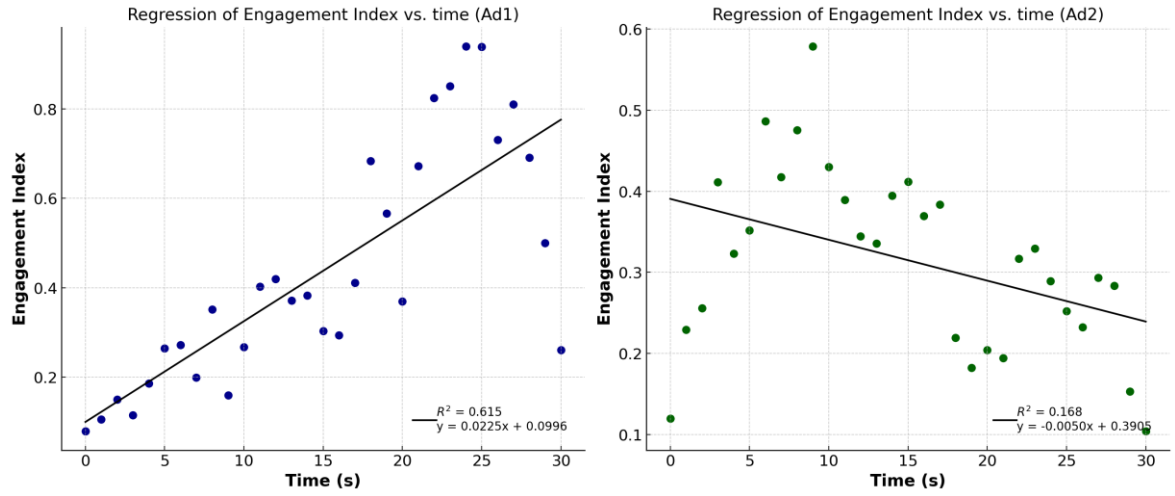

Figure 7. Linear regression of Engagement Index as a function of time for advertisements Ad1 and Ad2.

For advertisement Ad1, the linear regression equation is described by the formula y=0.0225x+0.0996. The positive value of the coefficient B=0.0225 indicates a positive relationship between time and engagement level (EI). This means that the longer the advertisement runs, the greater the viewer engagement. The linear regression model (R^2=0.615, p<0.01) explains 61.5% of the variance in the engagement index. Therefore, the duration of the advertisement is a robust and significant predictor of engagement in Ad1. For advertisement Ad2, a downward trend in viewer engagement can be observed throughout the ad. The formula y=-0.0050x+0.3905 describes the regression equation. The slope coefficient B=−0.0050 indicates that the EI decreases by an average of 0.0050 units for each subsequent second of the advertisement. The regression model (R^2=0.168, p=0.022) explains 16.8% of the variance in the engagement index. This means that the duration of the ad is a weak predictor of viewer engagement in Ad2. The application of the linear regression model thus allows for a better, more precise understanding of the dynamics of viewer engagement in the context of advertisement duration.

DISCUSSION

The study aimed to determine whether measuring brain activity could be effectively used to assess audience engagement with advertising content. According to models of advertising impact on audiences, successive phases of an advertising message should elicit specific reactions, such as attracting attention, generating interest, stimulating desire, or prompting action (purchase, behavior change) (Koziara, 2017). Engaging viewers in the reception of the message is, therefore, one of the critical elements of effective advertising (Zennifa et al., 2018), given the limitations of engagement assessment methods based on self-assessment questionnaires or behavioral measurements, which rely on the performance of specific tasks, (Zennifa et al., 2018) neurophysiological measurement (EEG) was chosen for this study.

The measurement of audience engagement with the advertising content using EEG enabled an objective capture of reactions to two different advertising spots. The first advertisement (Ad1) was broadcast by the electricity provider Energa. The Polish Ministry of Environment aired the second advertisement (Ad2). Advertisement Ad1, promoting energy saving through simple daily actions such as turning off the TV, turning off lights, or closing the laptop, showed a higher level of engagement (EI index) among viewers compared to advertisement Ad2. The higher engagement for Ad1 may be due to more engaging, unusual, and humorous elements, such as animals performing everyday tasks. The obtained results align with published research (Green & Brock, 2000; Heath, 2001), indicating that humor, surprising situations, and elements related to the audience's daily lives can significantly increase the effectiveness of advertising messages. Other studies suggest visual elements and actions that evoke emotions can enhance viewer engagement (Edson Escalas, 2004; Kim et al., 2017). Scenes involving the cat closing the laptop and the dog turning off the light can be considered such actions.

The analysis of the Engagement Index (EI) values for advertisement Ad1 indicates a gradual increase in viewer engagement, reaching its peak 5 seconds before the end of the advertisement. This pattern of increasing engagement is consistent with advertising impact models such as AIDA and Lavidge-Steiner. In the AIDA model, an ad should attract the viewer's attention at the beginning (Attention), then build interest (Interest), followed by desire (Desire), and finally prompt action (Action). Ad1 effectively captures attention and gradually builds interest and engagement, leading to a rise in EI as the advertisement progresses. Similarly, the Lavidge-Steiner model posits that a consumer moves through several stages from awareness (Awareness) to purchase (Purchase). Ad1 effectively supports this process by enhancing viewer engagement at each stage.

In contrast to Ad1, advertisement Ad2 showed a declining trend in viewer engagement as the advertisement progressed. The initial increase in engagement in Ad2, related to the couple's interaction in bed, was short-lived and did not sustain throughout the ad. In advertising impact models like DAGMAR, an advertisement should transition smoothly from unawareness (Unawareness) to action (Action), maintaining viewer engagement. The decline in engagement in Ad2 suggests that the ad needed to meet these assumptions, which may affect its effectiveness in capturing and retaining audience attention.

The analysis of engagement in individual time segments showed that more extended scenes in Ad1 (i.e., S3 – 9 sec. and S4 – 7 sec.) were associated with higher levels of engagement. These two longer scenes allowed for creating a more complete narrative, which

helps the viewer better understand the content of the message. The viewer has more time to engage with the presented message and identify with the characters and the situation depicted in the advertisement. By delving into the storyline, the viewer is more inclined to reflect on the message, which strengthens engagement. These conclusions are consistent with literature suggesting that longer, well-designed scenes can increase engagement through deeper information processing by viewers (Cartocci et al., 2019). In Ad2, a downward trend in engagement was observed as the ad progressed. Despite the fact that Ad2 had one long scene (S2 – 13 sec.), it can be said that it ultimately did not fulfill the expected role. It can be inferred that it was not designed well enough, as after an initial increase in engagement, it caused a subsequent decline. This led to a loss of attention, likely due to information overload, boredom, or message distraction, ultimately resulting in lower audience engagement. In Ad1, more extended scenes involving animals were more effective in maintaining viewer attention, aligning with advertising impact models that emphasize sustaining interest and engagement throughout the advertisement (Barry & Howard, 1990).

EEG as a method for measuring engagement enabled objective and precise capture of audience reactions at a neurophysiological level, consistent with previous research highlighting the advantages of physiological measurements. EEG allows for recording subtle changes in brain activity that are inaccessible through other research methods. The proposed methodological approach to studying audience engagement in ad reception is crucial in the context of advertising impact models. As is known, audience engagement with an advertisement affects the way in which viewers process information and respond to the advertising message. Depending on the level of engagement, the mechanisms of advertising action and its effects can vary significantly. The level of audience engagement determines how effectively the advertisement influences their decisions, attitudes, and behaviors. Different advertising models, however, emphasize the importance of this factor in different ways.

CONCLUSIONS

The conducted research focused on increasing energy awareness through effective advertising communication. A vital element of the study was using neurophysiological measurements, specifically electroencephalography (EEG), to assess audience engagement. Two advertisements promoting pro-environmental behaviors were analyzed. The aim was not only to understand how effectively the advertisements could capture attention and engage viewers but also to identify which elements of the message had the most significant impact on engagement. Additionally, the study examined how the level of engagement could influence different phases in selected advertising impact models.

The research findings suggest that using neurophysiological methods to measure engagement can be an effective tool for analyzing the impact of advertising messages on viewers. These studies can contribute to developing more effective communication strategies in social and commercial campaigns, potentially leading to more sustainable consumer behaviors. Organizations promoting appropriate behaviors and shaping energy awareness can use these research results to optimize their advertising messages. This approach can also be

effectively applied in other education and social awareness areas, such as ecology, safety, and health.

The proposed methodological approach to measuring audience engagement using EEG is an added value to advertising impact models. It provides objective data on brain responses, allowing a better understanding of which elements of the message truly capture attention and engage the audience. Traditional models rely mainly on subjective data (declarations, observations), whereas EEG offers deeper insights into cognitive and emotional processes occurring in real time. This makes it possible to precisely tailor social ads, such as those promoting energy awareness, to elicit greater engagement and lead to desired attitude changes. EEG also helps assess which moments in the ad have the most significant impact on the audience and which are emotionally engaging. As a result, neurophysiological measurement supports the creation of more effective advertising messages that are better suited to the audience and more effectively influence their attitudes and behaviors.

It is important to note that the study had its limitations. Firstly, the number of participants was relatively small (although sufficient for this type of research), which may affect the generalizability of the results. Additionally, the study focused on a randomly selected group of respondents, which may limit the ability to extrapolate the findings to a broader population. However, the presented methodological approach (research experiment, processing, and analysis of physiological data) can be applied to various research problems. The research could also be expanded to focus on the long-term effects of advertising campaigns. It would be valuable to analyze whether and how lasting changes in energy awareness and behaviors occur among viewers.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

The research findings suggest that applying neurophysiological methods for measuring engagement can effectively analyze the impact of advertising messages on viewers. These studies can contribute to developing more effective communication strategies in social campaigns (and commercial ones as well), which can lead to more sustainable consumer behaviors. Organizations that promote appropriate behaviors and shape awareness (including energy awareness) can use the research results to optimize their informational messages. The proposed methodological approach can be practical in advertising spots and other areas related to education and awareness, such as environmental, safety, or health awareness.

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