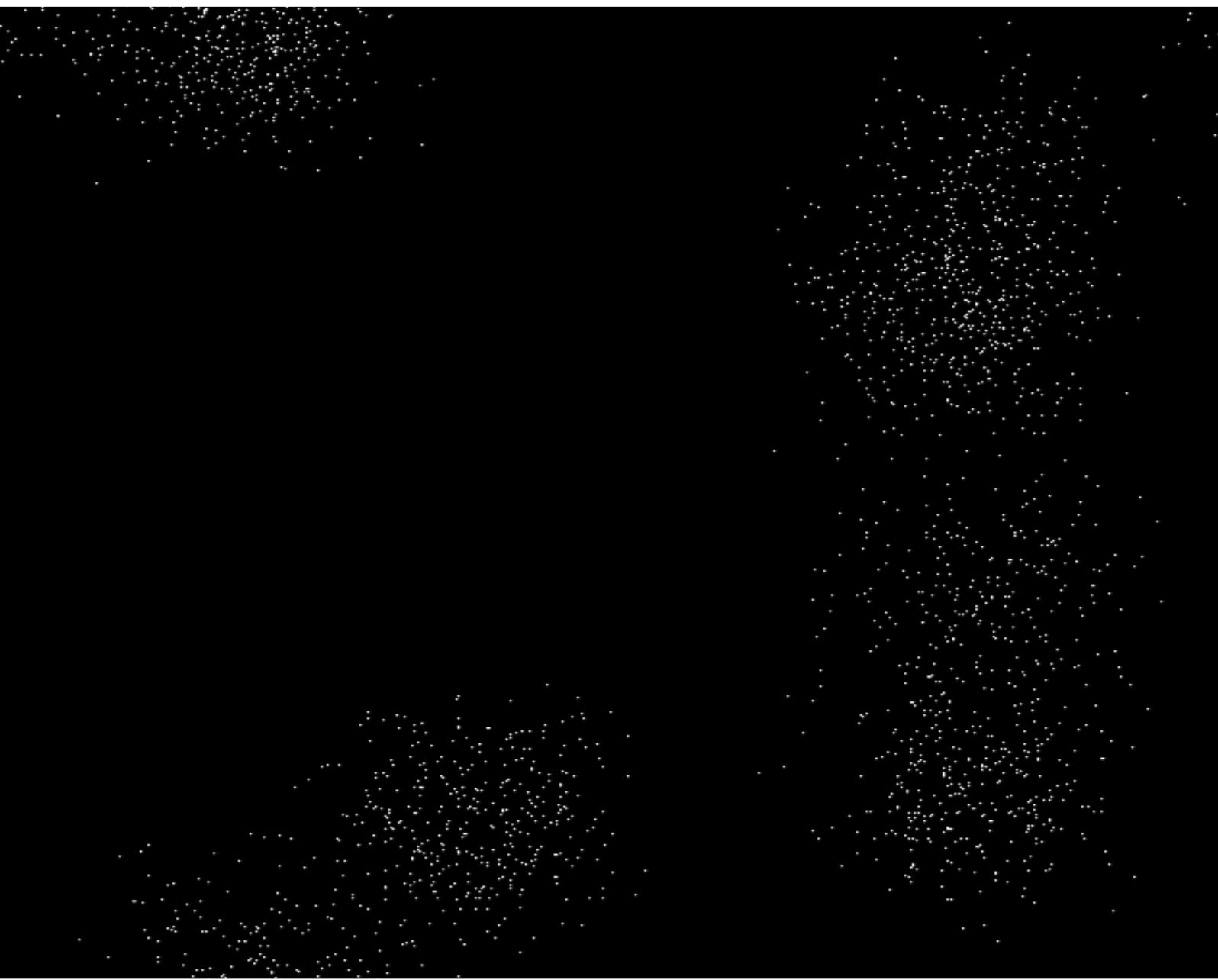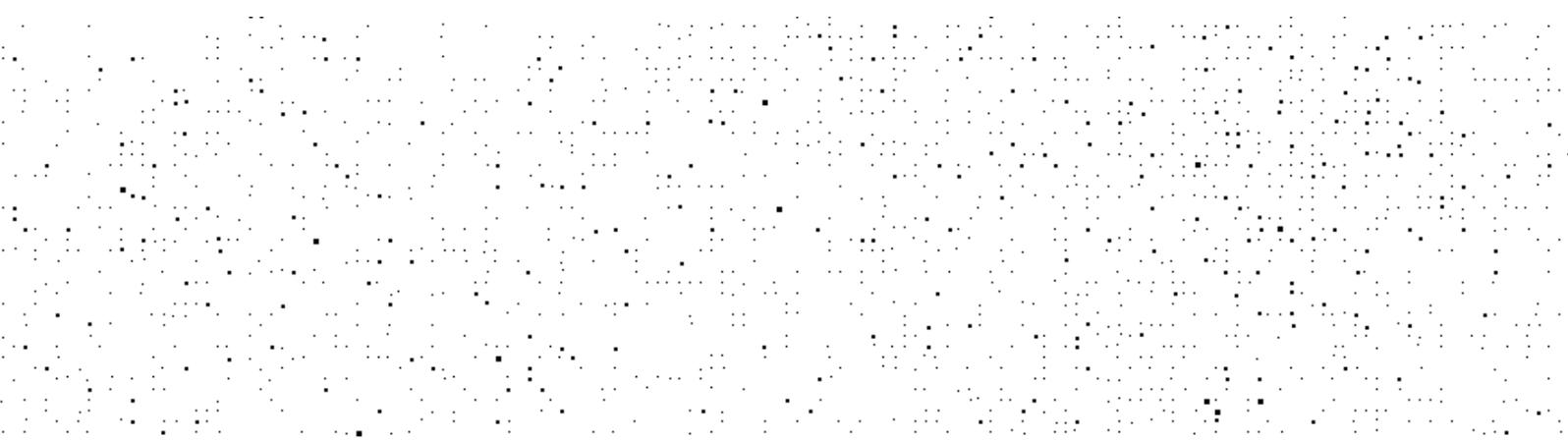# Informational Overload:
Essays and Visual Experiments
(Dynamic Visual Version)

Sadaf Jalalian, Polina Pashkina

This publication consists of investigations into informational overload by Miriam Arnold, Mascha Goldschmitt, and Thomas Rigotti *(Dealing with information overload: a comprehensive review);* Leila Shahrzadi, Ali Mansouri, Mousa Alavi, and Ahmad Shabani *(Causes, consequences, and strategies to deal with information overload: a scoping review);* Aarathi Prasad and Asia Quinones *(Digital overload warnings: "the right amount of shame?")* and *Visual Research by Sadaf Jalalian and Polina Pashkina.*

Informational Overload:
Essays and Visual Experiments

Introduction

This project explores print on demand as a way of translating auto-mated, digital content into a physical book. It focuses on information that is usually consumed quickly and forgotten just as fast, particularly weather data.

By slowing down constantly updated data and fixing it in print, the project reflects on our relationship to real-time information, the pressure to stay up to date, and the attempt to preserve something inherently temporary. Each book becomes a record of a moment that is already outdated.

The visual concept of the project is based on images generated through code. Live weather data is retrieved from APIs and directly influences the visual appearance of each page. The images are generated using weather forecasts with a maximum future range of sixteen days, emphasizing speculation, prediction, and the uncertainty of future information.

The publication combines essays addressing the speed of informa-tion, real-time culture, and moments of delay and pause. These texts do not explain weather directly, but approach it conceptually, treating weather forecasts as an extreme example of real-time information. Print on demand allows each copy to differ and makes change and obsolescence part of the work. The book is not intended as a final product, but as an experimental object shaped by data, time, and momentary conditions.

DEALING WITH INFORMATION OVERLOAD: A COMPREHENSIVE REVIEW

Miriam Arnold, Mascha Goldschmitt and Thomas Rigotti

1.   *Introduction*

With the digitalization of both work and private life, information is available in large quantities in digital form; we live in an "information society"[1]. It is possible to conveniently and actively access diverse information, and we also passively receive large amounts of information and messages. Despite the different channels of information, information is mostly consumed through screen displays. Bawden and Robinson[2] refer to this phenomenon as "homogenized diversity." Currently, the amount of information that is created every two days is roughly equivalent to the amount of information that was created between the beginning of human civilization and the year 2003[3]. The amount of information available has thus become excessive, but it is difficult to assess its quality. As a result, information overload has become a widespread problem. Indeed, information overload was cited as one of the most frequent stressors by 22.5% of respondents in a representative German sample[4]. The COVID-19 pandemic can be seen as a catalyst for these developments, and it seems likely that the resulting increased use of mobile working patterns, virtual meetings, and collaborative digital software will be permanent[5].

Empirical evidence shows that information overload is positively related to strain and burnout[6,7,8,] and various health complaints[9], and negatively related to job satisfaction[10]. Furthermore, information overload is associated with serious performance losses, especially in connection with disruptions and interruptions[11,12]. Finally, studies show that the quality of individuals' decisions is affected by information overload[13].

Given the relevance of information overload for the health and well-being of employees, as well as their performance outcomes, we provide a systematic review of preventive measures for information overload. Previous reviews on the topic of information overload aimed to identify the factors that influence information overload[14,8] or to present the consequences of information overload[8]. Furthermore, a meta-analysis focused on information characteristics as antecedents of information overload[15]. Although some review articles have examined the design or intervention options to counteract information overload, these are usually specific to one professional group (mainly medicine[16]).

Firstly, the aim of this review is to systematically describe the tools and interventions that can be used to manage information overload. The various recommendations and interventions are clustered according to the levels of the causes[14] or sources[15] of information overload. This clustering makes it possible to determine whether the recommendations address the amount of incoming information or, conversely, the handling of the incoming information. In addition, this study assesses the extent to which preventive measures are proposed in terms of behavioral versus design solutions.

Secondly, we aim to assess the current state of knowledge on design recommendations for information overload. We will also examine whether the guidelines and recommendations are concrete or still relatively vague and thus identify the areas in which knowledge deficits remain.

2.   *Theoretical classification and definitions*

Several papers have already addressed the theoretical grouping of the factors that contribute to information overload and the consequences of information overload[14,15]. These models thus provide a theoretical framework for the present review. In addition, cognitive load theory[17] and media richness theory[18] are often referred to in the literature on information overload.

In their framework model of the concept of information overload, Eppler and Mengis suggest that there are several interrelated causes of information overload: the characteristics of the person receiving the information, the characteristics of the information, tasks and processes, organizational processes, and information technology[14]. The resulting consequences of information overload require the use of countermeasures, which, in turn, affect the causes of information overload. This process is circular, and all the aspects are interdependent[14].

Cognitive load theory suggests that the human working memory is limited to approximately seven ± two units of information[17]. Accordingly, information overload occurs when the amount of information exceeds the working memory of the person receiving it[15]. Cognitive load theory identifies three different categories of cognitive load: extraneous, intrinsic, and germane cognitive load. Extraneous cognitive load is influenced by the design of the information[19]. Intrinsic cognitive load results from the content of the information, such

as its complexity. Finally, germane cognitive load is the favorable, learning-enhancing cognitive load that results from focused engagement with the information. Ideally, this final form of cognitive load leads to the construction of schemata and mental models[19]. Media richness theory also provides a theoretical framework for studying information overload. One of the goals of using information and communication technology (ICT) is to reduce the ambiguity of information[18]. Therefore, information richness, which refers to the extent to which information can change understanding in a given time interval[18], should be considered in relation to information overload. In addition to the information itself, the various possible communication channels may also differ in their richness. Face-to-face conversations are thought to be the richest form of communication, while letters or e-mails are less rich[18,20]. Cognitive load theory provides a precise definition of information overload, while the media richness theory better supports the development of design interventions. Against the background of these relevant theories, the terms used in this study can be defined.

Information overload is a topic that is relevant to many disciplines, including medicine, social sciences, marketing, computer science, education, and psychology[21]. This means that there is no single, universally accepted definition. In everyday language, information overload is often equated with receiving too much information[14]. According to Klausegger et al., a consistent feature of the various scientific definitions of information overload is that the amount of information is initially related to better performance or better decisions but that, above a certain amount of information, the effect changes, and the amount of information leads to worse outcomes (an inverted U-shaped relationship[14,22]). More specifically, Klapp defined information overload as an excessive amount of information that the receiver can no longer process efficiently without distraction, stress, increased errors, or other costs that reduce the efficient use of the information[23]. Similarly, Eppler and Mengis argued that information overload occurs when the amount of information exceeds the processing capacity of the recipient[14].

As mentioned above, information overload is closely related to the use of ICT and, therefore, also to the concept of technostress. Technostress can be defined as the stress experienced by individuals due to the use of ICTs[24]. Information overload and constant availability are the two main stressors caused by the use of ICTs[25]. Therefore, information overload can be seen as a feature of technostress. Although this review focuses on information overload, it also includes primary studies that refer to both technostress and information overload. Five techno-stressors are commonly discussed in the technostress literature: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty[25]. Factors with the potential to buffer the detrimental effects of techno-stressors on employee well-being are discussed under the label of techno-inhibitors[24,26]. Examples of techno-inhibitors are literacy, participation, or innovation support[27,26].

3. Methods
3.1. Search strategy

Following the recommendation by Methley et al. we used the PICO tool in order to define our keywords in both English and German[28]. As the discussion on information overload comes from several fields, many synonyms for information overload are used. To cover these, we included a large number of synonyms as outcomes in our search string, linked with an OR operator. As we are interested in methods and interventions to reduce information overload, a further part of the search string refers to aspects that could be used as countermeasures against information overload. In order to also cover a wide range of potential countermeasures, we included "software" as a keyword beneath the more psychological aspects of intervention, training, workshops, or work and task design. In addition, to address individual strategies, we included the keyword "coping strategies." As described, the focus of this review is on information overload in the workplace, so a third set of keywords defining the population was added to ensure the relevance of the search results to the workplace. In order not to narrow down the results further than necessary, keywords in the comparison category were omitted.

In the second step, we defined the databases to be searched. We searched the scientific databases Web of Science, Ebscohost, Medline, PsycInfo, and PsycArticles using complete search strings with Boolean operators. With the aim of including the applied

literature, we also searched other practice-oriented databases, including PSYNDEX Interventions, Rehadat, Arbeitssicherheit.de, publications of the Federal Institute for Occupational Safety and Health (BAuA), and publications of the Verwaltungs -Berufsgenossenschaft (VBG). As most of these platforms do not allow searches using Boolean operators, all synonyms for information overload were used individually as keywords.

In the subsequent review process, we followed the PRISMA standards[29] and accordingly recorded how many results were obtained from the literature searches conducted in this way. Following the literature search, all duplicates were removed, and two independent raters classified the search results as relevant or irrelevant to the research question on the basis of titles and abstracts (screening). The screening process itself was blinded. If the two raters disagreed about certain identified documents, a joint decision about inclusion or exclusion was made. We then read the full texts of the documents that were deemed relevant, which led to further exclusions if they did not fit the research question (suitability).

In the final step, we coded and categorized the content of the eligible documents. We recorded the level of the intervention (person, information, tasks and processes, organizational processes, information technology), a precise description of the intervention, the type of article, the research question, the study design, the sample, the results, and the implications in terms of recommendations for action and the person who should implement them.

3.2. Inclusion and exclusion criteria

Due to the rapid development of ICT, the time frame of the search was limited to the period from 2000 to 2021. We included the following: 1 evaluation studies on concrete interventions; 2 scientific studies allowing conclusions about design options for dealing with information overload; 3 studies on information quality; 4 studies on the design of work-relevant information to facilitate processing; 5 studies on knowledge management with relevance for preventing information overload; 6 studies providing advice on workshop content at the individual level; and 7 studies presenting examples of specific software for managing large amounts of information. We excluded: 1 papers referring exclusively to multitasking without addressing information overload; 2 papers on ICT use outside working hours or information overload related to social media; 3 purely technical papers on data storage or methodological ICT solutions; 4 consumer research and customer communication studies, especially recommendation systems; and 5 occupation-specific design recommendations (e.g., librarians, molecular biologists, autonomous driving, studying and teaching, or patient-centered medical knowledge). A total of 1,054 papers were extracted from the scientific databases, of which 72 were identified as suitable after screening. From the practice-oriented databases, 259 papers were extracted, of which 15 were identified as suitable and included in the review.

3.3. Intervention and design approaches

The causes of information overload can be found at the societal as well as the organizational and interpersonal levels. At the societal level, accelerated information production and rapid dissemination via the internet contribute to information overload. These societal aspects are difficult to influence through occupational health management.

At the organizational and interpersonal levels, information overload can be caused by five aspects: 1 information, 2 person, 3 tasks and processes, 4 organizational processes, and 5 information and communication technology[14].

Information characteristics relevant to information overload include quantity, frequency, intensity, and quality. Other general characteristics of information may also play a role[14]. Graf and Antoni report that information complexity, ambiguity, novelty, and structure are particularly relevant[15].

At the person level, characteristics of the individual receiving, processing, or communicating information are relevant. Attitudes, qualifications, experience, competencies, skills, and motivation influence whether a given amount of information results in information overload[14].

At the level of tasks and processes, information overload can arise from the work tasks themselves or from cooperation with others. Routine procedures reduce required

processing capacity, whereas complex and novel procedures increase the likelihood of information overload[14].

Organizational processes include formal and informal work structures[14]. Changes in organizational processes and team structures may increase information load, whereas standardization and regulations can reduce the risk of information overload.

At the level of information and communication technology, both the choice of technologies and their use are relevant. The emergence of new technologies, such as widespread e-mail use, plays a major role in information overload[14]. It is therefore crucial to leverage technological opportunities while minimizing associated risks.

These five levels serve as starting points for design options and interventions to address information overload. Accordingly, the results of this review are structured along these levels. Design recommendations at the person level are classified as behavioral prevention measures, while recommendations at the other four levels are considered structural prevention measures.

4. Results
4.1. Level of information

According to Graf and Antoni, a distinction can be made between information quantity and information quality, and both are related to information overload[15]. Quantity is mainly understood as the objective amount of information. However, when subjective perceptions are considered, contradictory results emerge. Empirical studies suggest both positive and negative correlations between information quantity and information overload[15]. This indicates that subjective assessments are influenced by available resources and individuals' ability to manage incoming information.

Positive correlation between the quantity of information and information overload, but at the same time some studies have reported a negative correlation between these two variables[15]. It can therefore be assumed that the subjective assessment of the quantity of information may be influenced by the available resources and the individual's ability to manage the incoming information. The quality of information includes various aspects that contribute to the fit of the information to the needs of the person receiving it. These aspects include, for example, the complexity or relevance of the information.

With regard to the quantity of information, it should be noted that a large number of papers have described the use of various information technologies to reduce the quantity of information. Therefore, papers that mainly describe and evaluate these technologies and thus address the problem of high information quantity are included in the section on information technology.

4.1.1. Quality and presentation of information

Much of the literature on the presentation of information relates to the medical field. Indeed, the condition of critically ill patients can be affected if an important piece of information is overlooked, and time pressure is often high in medicine. Beasley et al.[30] showed that problems of complex "information chaos" are particularly relevant in the medical field. Information overload is often cited as one aspect, along with information deficits, information conflicts, and scattered or incorrect information. The following papers each address one or more of these aspects.

Based on 17 primary studies, Khairat et al.16 reported in their review that visualization dashboards reduce the time spent collecting data, the difficulty of the data collection process, the cognitive load, the time to task completion, and the error rate. These visualization dashboards also improve situational awareness, adherence to evidence-based safety guidelines, ease of use, and navigation through the program. Therefore, the presentation of selected critical patient data in a clear manner can be recommended in

clinical settings. Another review with the same target group indicated that more than half of the included peer-reviewed primary studies (12 out of 22) on dashboard implementation showed positive effects on outcomes such as patient health, process outcomes, efficiency, and costs[31]. However, the authors reported that the empirical evidence on the effectiveness of dashboard implementation in clinical settings is limited by the low to moderate quality of the primary studies. It should also be noted that these studies rarely

considered information overload as an outcome.

Three other original studies also address the clinical application context. Patapovas et al.[33] tested a clinical decision support system, but since the study did not implement a pre-and post-survey and did not include a controlled-randomized design, the results only permit the conclusion that the test users used the electronic patient record regularly. Ahmed et al.[34] compared a new format for representing information with an established format. With the new format of representation (reduction, filtering, and better categorization of patient data), the test subjects showed better performance, faster processing times, and most importantly also a lower task and information load. The study suggests that the reduction, filtering, and better categorization of patient data have a positive effect on reducing the effort required to process the information. Another dashboard for the clinical context was developed and tested by Tan et al.[35] based on Toyota's Andon Board. The dashboard extracts data from electronic patient records every minute and notifies clinicians of urgent orders (e.g., laboratory tests, medications, etc.), abnormal laboratory and radiology results, and infection alerts. Overall, the dashboard seems recommendable; in the study, it ensured efficient and safe work and was well accepted by the users. However, this empirical evidence is limited due to the lack of a control group.

In a different work context (an LED factory) but still with a similar approach, Wu et al.[36] used eye tracking to investigate three different levels of complexity in the presentation of technical information at the human-machine interface. The results showed that the time it took the subjects to fixate on the target object differed significantly depending on the complexity of the presented information. Specifically, fixation was fastest in the low complexity condition. Another finding was that the search patterns of novices were significantly more complex than those of experts. Furthermore, experts reported lower cognitive load than novices. Overall, these findings suggest that user interfaces should be designed to be as simple and clear as possible while still providing the necessary level of functionality. Furthermore, the same amount of information may have different effects depending on the professional experience of the individual. Indeed, Ries and Deml[37] reported a similar conclusion in relation to the work of control room staff; they also proposed specific recommendations on how to optimize the presentation of information in the form of video recordings.

Wnuk et al.[38] proposed a way to visualize the content and progress of a project. This tool, called FSC+ (Feature Survival Chart), is specifically aimed at the fields of business management or project management. The tool makes it possible to visualize the scope of a project and to show the dwell time of individual project steps in the project, thus facilitating project decision making. A test of the tool with 20 sample users showed that the interviewees were positive about the tool. However, the learning curve for using the tool was longer than expected. The study showed that the tool is more useful for people who need to work with large amounts of data and information, while the tool is less useful for people who only need an overview of a limited number of project steps. The study provides weak evidence that the FSC+ tool can be used in project management and project leadership to reduce information overload.

Roy et al.[39] addressed the question of how to increase management's knowledge of processes within the organization without leading to information overload. Based on an unsystematic review, the authors proposed the following solutions at the knowledge level: the use of summaries, comments by experts, indicators, and priority setting, the distribution of information over time, and the visualization of information. Solutions based on the use of digital media were as follows: the use of search engines, blogs, dashboards, news and updates, notes and virtual bookmarks, and alerts. In addition, with the aim of providing relevant information to decision makers in companies, Dzokoto et al.[40] proposed a "SMART Push System" based on a literature review. This system actively suggests the relevant documents or content to decision-makers, taking into account all the available information and contextual knowledge, without them having to actively request the information. However, this article was only a conceptual work.

Riener and Ferscha[41] took a different approach, initially independent of the work context. They proposed the use of tactile stimuli to relieve the visual and auditory sensory channels. Their study focused exclusively on spatial orientation and tested the use of a vibrotactile belt to inform subjects about the spatial distance to a target object. Based on the results of the study, we cautiously conclude that it may be useful to use tactile stimuli to convey information. However, the participants only showed a learning effect when they were informed about the accuracy of their distance estimations, whereas their estimation

performance deteriorated when no feedback was provided.

4.1.2. Quantity of information

Shah et al.[42] examined the quantity of information sent to primary care providers through the Department of Veterans Affairs in the US. They also looked at new regulations to filter the information sent, as well as staff training on how to individually enable and disable certain types of messages. The study showed that the number of daily messages could be reduced with these policies, but no concrete impact or evaluation of the staff training was reported. It should also be noted that there was no control group and that the implementation of the intervention varied between regions.

Another study in the clinical work context by Pickering et al.[43] examined the information used by intensive care unit (ICU) staff when a new patient is admitted. The aim of the study was to identify the type of information that needs to be prioritized in the ICU. To answer this question, observations and interviews were conducted over 1.5 years in three different ICUs. Out of a total of 51 different clinical information concepts, an average of 11 concepts were used when a single patient was admitted. The four most commonly used concepts were heart rate, oxygen saturation, respiration, and blood pressure, and each was used in more than half of the admissions. The study suggests that when a patient is transferred to the ICU, certain information should be presented in a prioritized manner. Access to other information should not be prevented, but the most commonly used categories of information should be presented in a clear and concise manner.

Another approach to reducing the amount of information or helping individuals remember the most important information was examined in a Cochrane systematic review by Arditi et al.[44]. They focused on computer-generated reminders provided in paper to healthcare professionals. The data from 34 individual studies showed that this form of intervention significantly improved the quality of care. There was also weak evidence that patient outcomes could be positively influenced by these reminders. However, the extent to which this intervention could reduce information overload for health professionals was not investigated.

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4.1.3. Summary: level of information

Empirical evidence on the quantity and quality of information to reduce information overload focuses mainly on the digital representation of information. When designing software, it is important to ensure that the amount of information presented is manageable and customizable. At the same time, in the software, it should be possible to intuitively access background information that is not visible at first glance. Design principles and design laws should also be considered. Although the studies to date are of relatively moderate quality (e.g., few have used a randomized control group design) and mainly relate to the medical field, the findings are also applicable to other professional groups for whom it is essential to have important information presented as clearly as possible (e.g., employees in control rooms or managers). Based on the literature presented here, the use of dashboards appears to be recommended.

4.2. Person level

At the individual level, the literature included in this review offers some advice on how to manage information and information overload in general. Specifically, information overload can be addressed at the personal level through education. Furthermore, we present recommendations on how to deal with e-mail and the Internet in general. The following section also includes suggestions on how to actively manage the boundaries between work and leisure time and the workplace itself.

4.2.1. Dealing with information overload

Information overload should be recognized as early as possible[45] and proactively addressed at the individual level[46]. Landale[46] presented a three-step approach that can be applied by individuals in combination with memory training: Receive and evaluate the document and decide whether to read it, delegate it, or ignore it. Gain an initial under-

standing of the document and decide whether to read it in detail and, if so, how quickly and how deeply. Adapt the new knowledge. Similarly, Warbington[47] recommended that when receiving information, one should first clarify the goal one is trying to achieve, from which the importance of different pieces of information can be assessed. Accordingly, a survey of 124 managers by Farhoomand and Drury[48] and an editorial by Kluge et al.[49] suggest that filtering information is seen as a helpful measure against information overload. This filtering can be achieved, for example, by suppressing, deleting, or selecting irrelevant information[49]. In the process of filtering or screening, according to Farhoomand and Drury[48], delegating work is also an option, and this delegation should be directed not only to colleagues but also, if possible, to digital agents[49]. Finally, prioritizing information can also be a helpful action to manage information overload[48].

Mindfulness also plays a role in managing information overload, and according to an unsystematic review by Stich et al.[50], mindfulness skills should be developed in order to manage e-mail-related information overload. Mindfulness can be assessed and improved through questionnaires that measure and provide feedback on the level of strain experienced by information overload or attitudes toward ICT.

4.2.2.   Training

At the individual level, previous studies have recommended attending training to reduce and prevent information overload[51,52], with companies in particular being encouraged to invest in such training for their employees. However, Pfaffinger et al.[53] also suggest that individuals should proactively demand further training opportunities.

A review by Antoni and Ellwart[17] made it clear that individuals are able to process a large amount of complex information if they have the competencies to use modern ICT. These skills should be trained through further education, for example, on the functionalities of these technologies. Furthermore, according to Nagarajah[54], the introduction of new technologies should be accompanied by adequate training in order to prevent technostress. Specifically, in addition to the training in digital skills[51,55], the literature recommends improving media and information literacy[56,57,51]. With regard to the use of software, this literacy includes, for example, learning helpful but often unknown functions of the software[56].

Based on a case study, Cheuk[58] also suggested that information literacy is a human resource development issue in four dimensions: Skillful use of information at a strategic level. Organization and control of information. Knowledge of access and tools. Linking of finding and using information. In addition, individuals should be taught appropriate work strategies to deal with information overload, such as how to manage large amounts of information[56]. These strategies could include improving self- and time management, as these are effective measures against information overload[56,51].

According to a quantitative study by Yener et al.[59], in addition to training in time management, technological self-efficacy training could also counteract the negative effects of technostress on burnout and performance. Mahapatra and Pati[60] highlighted that techno-invasion and techno-insecurity are also positively related to burnout, while the latter mediates the relationship between techno-complexity and burnout[60]. Therefore, techno-insecurity and perceived techno-complexity should also be addressed in training measures. The study by Le Roux and Botha[61] provides a complementary reference to these findings, as their work showed that perceived techno-complexity and techno-uncertainty increase with age. Consequently, training in this area should be provided to older employees in particular.

Zhao et al.[62] suggested further avenues for interventions to address information overload. First, problem-focused coping (e.g., performing a cognitive assessment of technostress and seeking instrumental support) is helpful in alleviating information overload. Second, training in emotion-focused coping or venting is also recommended. Based on this, Becker et al.[63] found in a quantitative study with 3,363 knowledge workers from Germany that coping strategies reduced the negative indirect relationship between technostress and performance mediated by exhaustion. Therefore, the authors recommend that different coping strategies should be trained. Although both dysfunctional (avoidance of the problem) and active-functional (including problem-focused and emotion-focused coping) coping strategies reduce the strain caused by techno-stressors, the negative long-term consequences of dysfunctional coping should be explained to individuals, and in

particular, active-functional strategies should be part of further training measures.

A cross-sectional study by Yin et al.[64] focused on the timeliness of information processing, which refers to the perceived support for timely information provided by mobile ICT. Their study found that the timeliness of information processing reinforces the negative relationship between information overload and job satisfaction and is therefore not recommended as a coping mechanism.

Based on their qualitative and quantitative study results, Moser et al.[65] developed an exemplary training concept to be applied at the personal level, including the following aspects: know-how, efficient handling of information overload, time management methods, and training on e-mail programs. The training was highly accepted by the participants, led to an increase in knowledge, and reduced the participants' feeling of information overload.

In a quantitative intervention study, Soucek and Moser[66] examined a training intervention to explain the use of modern ICT, and their results showed that e-mail communication could be improved by training in media literacy, individual work processes, and knowledge of the principles of e-mail communication. According to Bundesanstalt für Arbeitsschutz und Arbeitsmedizin BAuA[56] and Stich et al.[50], training-based interventions in relation to e-mail use should also include "netiquette" (i.e., topics such as virtual politeness, respect, and commitment). With regard to training on e-mail use, Antoni and Ellwart[17] further noted that individuals should be made aware of the negative effects of e-mail interruptions and should be presented with concrete techniques for managing e-mails efficiently. For example, setting fixed times for processing e-mails can be helpful. A concrete example of an intervention that has already been developed and evaluated is the training program of the initiative "New Quality of Work," which includes modules on the organizing of incoming mail, processing and managing e-mails, and designing correspondence[56]. According to Moser and Soucek[67], a needs analysis is required before a training intervention should be offered in a company. Ultimately, a shared e-mail culture can be developed through joint participation in the program.

De Bruin et al.[68] showed a positive effect of mindfulness training with regard to stress (measured by the Perceived Stress Scale). However, a positive effect of mindfulness training specifically on information overload cannot be inferred from these findings. According to an interview study by Camargo[69], other creative solutions, such as learning videos or presentations, can also contribute to the further training of employees in relation to managing information overload.

4.2.3.   Dealing with E-mails

According to Drössler et al.[51], managing e-mails poses a challenge for employees in terms of information overload. Indeed, both individuals and organizations should take responsibility for implementing measures to address this issue, which can be done by creating a detailed information culture in the company and clear internal company regulations, such as communication and e-mail guidelines[56,70,51,50,52]. Soucek[66] also recommended structuring and managing the inbox, scheduling e-mail communication, and using e-mail correspondence in a manner appropriate to the medium.

Clear articulation of concerns related to task objectives is considered important in e-mail communication. Furthermore, in order to avoid unnecessary communication, it should be made clear whether further action is required as a result of the e-mail sent and, if so, what form this action is expected to take (e.g., how quickly a response is expected)[71,70]. In addition, the necessity of the information should be questioned before sending an e-mail communication, and e-mails should only be sent to relevant recipients[72]. Standard templates can be used to reduce the effort required to formulate e-mails[71]. Furthermore, the group of people to whom the information is disseminated should be limited by avoiding the use of carbon copies CC and forwarding e-mails[71,70,51], the amount of information disseminated by e-mail should be kept as small as possible, and large attachments should be avoided[71]. So-called "buck-passing" (i.e., passing on a task to another person by forwarding an e-mail) should be avoided[70], but blind copying BCC should be retained if deemed appropriate, as there are usually good reasons for using this functionality. However, duplicate communication through multiple channels should be avoided[51]. Individuals should refrain from regular follow-up e-mails[70] and instead consider other methods of communication, such as face-to-face contact instead of e-mail[69,71,51]. In

addition to individual strategies, such as skimming (reading quickly to get a general overview), automated filters in the inbox can also be helpful for recipients of large amounts of e-mail information[72]. Indeed, developing rules and filters and integrating them into one's e-mail use can help separate important e-mails from irrelevant information, such as spam[69]. Ramsay and Renaud[70] recommend ignoring or deleting potentially risky e-mails as a measure against information overload. This approach is particularly useful when virus-laden content is suspected.

To counteract the accumulation of information, subscriptions to automated services such as newsletters or newsfeeds should be made selectively[51]. Similarly, individuals should also inform their colleagues directly if they do not need information sent via their e-mail distribution lists[69].

To protect individuals from compulsive e-mail checking, Ramsay and Renaud[70] recommended two strategies. First, colleagues should accept that individuals have different ways of managing e-mails in terms of how often they read them. Second, individuals should free themselves from the expectation that e-mails should be answered outside of work hours, thus allowing them to make a clear distinction between work and private life[69].

4.2.4. Dealing with the Internet

A report by the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)[71] provides concrete recommendations on how to manage the Internet in general. In particular, the use of meaningful and concise search terms is recommended to significantly reduce the number of search results. In addition, the topics of documents and materials from the internet should be checked immediately to eliminate information that is not relevant. The basic principle of these recommendations is to identify only as many documents on a topic as can be processed in a reasonable amount of time. According to the authors, a clear filing system can help navigate through the information. Furthermore, when working with the Internet, direct communication with colleagues about the perceived importance and relevance of various documents can also reduce one's own information overload[71]. Finally, a systematic review by Drössler et al.[51] suggested that active information searches should be used instead of push notifications.

4.2.5. Active design of the workplace

Pfaffinger et al.[53] report that active workplace design and boundary management can be helpful against information overload. In fact, an interview study by Camargo[69] with 17 employees in the "high technology" sector also found that separating work and private life can reduce the stress caused by e-mails.

Soucek and Moser[66] recommended self-management techniques, such as prioritizing and sequencing tasks according to one's needs, to improve individual workflows. For example, managing e-mails should be integrated into an individual's daily schedule at a time that makes sense for them.

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)[71] recommends actively creating time for breaks and reducing interruptions during these times, which can be achieved, for example, by switching off the incoming notifications for e-mails[51]. Finally, to reduce technostress, no e-mails should be processed or sent outside of working hours[73].

4.2.6. Summary: person level

At the individual level, several studies have recommended that individuals participate in training interventions that, in addition to supporting the development of general competencies such as self- and time management, should improve their competencies in managing ICT and the software used in the company. However, there is a lack of methodologically sound empirical studies that test the effectiveness of the proposed intervention approaches. In fact, we identified only two evaluated interventions that reduced subjective information overload among participants, but these studies did not include any objective measures. In terms of avoiding information overload, e-mail management seems to be particularly challenging. In addition to participating in training, studies have suggested concrete actions that individuals can take to counteract information overload. An example is to organize one's workplace in a way that supports the setting and

maintaining of boundaries between work and private life and creates free spaces and breaks. It should be noted that while the advice for individuals is presented at the individual level, the support of the company in the implementation of these strategies is elementary. For example, the company's regulations, the corporate culture, or human resource development policies may be important in helping employees manage information overload. Figure 2 provides an overview of the suggested content for training.

4.3. *Level of tasks and processes*

At the task and process level, it may be useful to standardize certain procedures to address information overload[15]. Piecha and Hacker[74] and Piecha[75] presented a detailed report on a multi-year multi-method research project on information overload. The aim of the report was to identify approaches to managing a large amount of information transmitted through ICT at work in a non-overwhelming way. From their systematic field studies, the authors derived several recommendations. These include the needs-based design of the media landscape, the regulation of organizational information flows, the adequate measurement of time when working with digital media, the reduction of parallelism and diversity of tasks, the development of employees and managers, and the individual planning of work[74].

In addition, Stadin et al.[52] interviewed 20 health care managers in Sweden using the critical incident method. The negative aspects of digital communication mentioned were high workload, the invasion of privacy, and negative feelings, for example fear of missing something in the e-mail inbox. Promoting digital literacy, designing ICT according to needs, and redistributing work and ICT systems were mentioned as possible solutions to the negative aspects of digital communication. Furthermore, e-mail culture, support from colleagues, individual resources such as routines and structures, individual competencies such as learning by doing or preparation, and organizational resources such as IT support were mentioned as important aspects in dealing with information overload.

Stich et al.[50] highlighted the negative consequences of excessive use of digital information technology and ICT: technology overload, interruptions, multitasking, work-home interference, and cyber deviance. The following process recommendations were made to address these issues: first, establish clear policies on ICT use, for example blocking e-mail traffic outside working hours, switching from e-mail to an internal social network, establishing policies against cyberbullying or regarding ICT use in general; second, implement individual interventions; third, create individual mindfulness, for example measure and provide feedback on the level of technostress or attitude toward ICT through surveys; fourth, create mindfulness toward colleagues, which is a particular responsibility of managers, but colleagues should also be asked which communication channels they prefer.

Bordi et al.[76] introduced the term information ergonomics, focusing on the workload induced by information-intensive tasks. In their study, discussions in several focus groups with a total of 36 employees, including insurance and financial service providers, were qualitatively evaluated. The following aspects were identified in the discussions: the establishment of common rules or etiquette, quiet times, training in the use of tools, and prioritization.

In their editorial, Kluge et al.[50] discussed the filtering of information as a measure to address information overload. They also emphasized that tasks can be delegated from humans to digital agents and that management information systems and interactive assistance systems can be used to reduce information overload. Effective measures also include organizational unlearning, which refers to forgetting information that is no longer relevant.

Okolo et al.[77] conducted a cross-sectional study with 319 bank employees in Nigeria to examine the indirect relationship between job-related resources according to the Job Characteristics Model, that is task feedback, task autonomy, task significance, task identity, and skill variety, and work engagement mediated by the experience of technostress. Technostressors, namely overload, complexity, and invasion, could be categorized as challenging demands, defined as a demand that shows motivational effects in addition to being straining. Activity resources showed a positive indirect relationship with work engagement mediated by technostress. Concrete recommendations for action cannot be derived from this study, but the indication that experienced technostress may

23.01.2026
Temp: -4.9°C
Rain: 0 mm
Wind: 13.4 m/s
Cloud: 45%
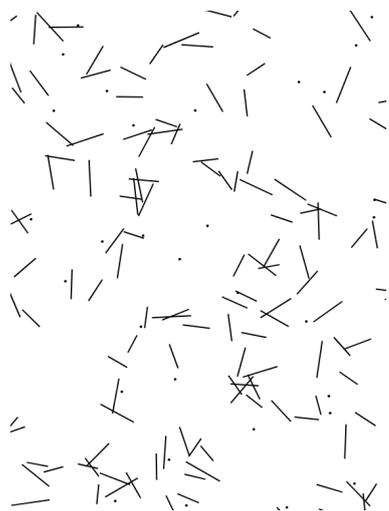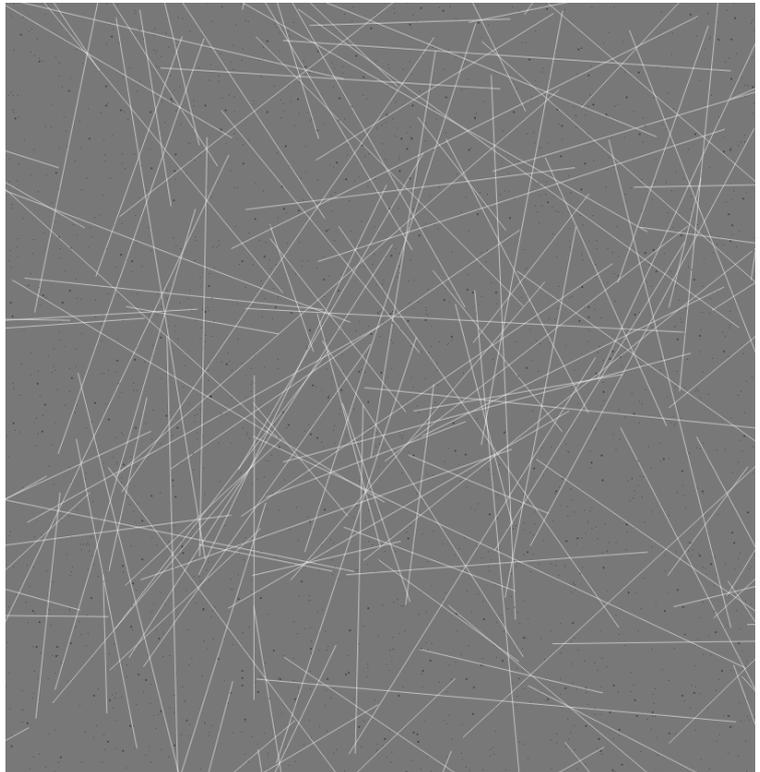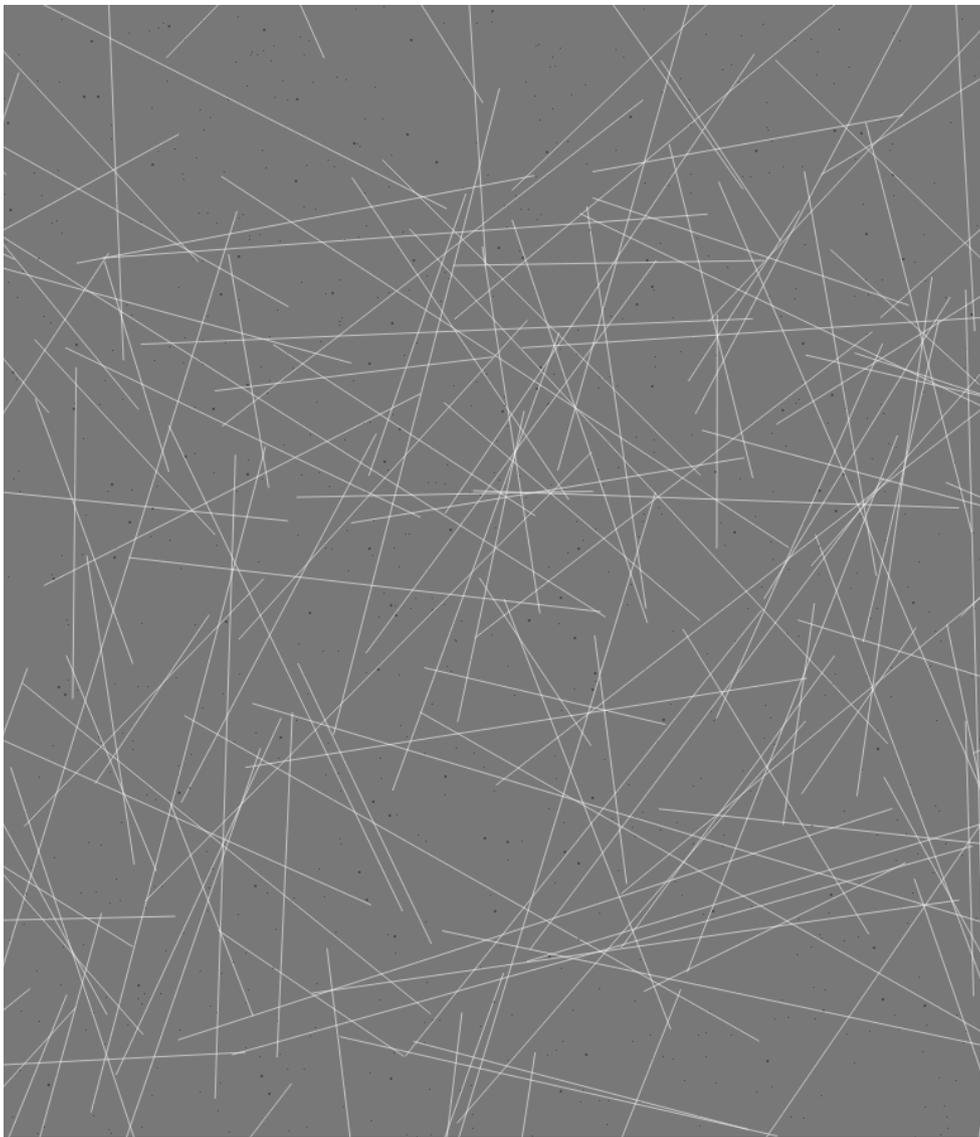
have the potential to act as a challenge suggests that motivational gains may be derived from technostress under certain conditions.

Oldroyd and Morris[78] focused on a specific group of employees, the so-called high performers or stars, whose productivity can be up to ten times higher than the average in an occupational field. Such stars tend to be very well connected socially, which means that the amount of communication and thus the information load they experience is very high. To maintain the productivity of such stars, the authors suggest, among other things, training in the ability to distinguish between useful and superfluous information, the formation of schemas to support long-term memory, decision latitude, supportive colleagues, reducing the breadth of the social network while increasing the density, and distributing standardized information to the entire network instead of individualized information.

The authors also made other recommendations at the organizational level: clarify where information can be found, increase the cost of sharing information, use information systems to contextualize information and make it more useful to employees, create special knowledge-sharing positions for star employees, and encourage relationships with other star employees. Some of these recommendations do not appear to be limited to star employees.

4.3.1.   Cooperation in teams

Ellwart et al.[79] evaluated an online intervention for structuring teamwork (STROTA), which was shown to reduce information overload. In the STROTA intervention, team members are first encouraged to analyze the current situation with regard to the triggers and conditions of experienced information overload in a structured way. Then, a facilitated team discussion creates a shared mental model and situational awareness (team situation awareness), and the team develops concrete goals and plans (team adaptation).

Based on interviews with 10 emergency responders with leadership roles, Norri-Sederholm et al.[80] also emphasized the importance of situational awareness, which depends on having relevant information available. Paul and Nazareth[81] used a group support system to regulate the flow of information within a team, helping them to process information effectively despite high complexity. As an intervention, the groups were given access to aggregated information from the work of previous groups engaged in a similar decision situation. In terms of the results, the provision of a decision scheme cannot be unconditionally recommended, as the expected effect, namely a higher threshold for the occurrence of information overload, did not occur. Instead, the relationship between information complexity, time pressure, and time to decision changed fundamentally to a U-shaped relationship in the treatment group. Specifically, at high levels of information complexity, the decision time was longer when the decision scheme was available to the group. Therefore, the advantages of having a schematic summary of information are only relevant for information of medium complexity.

Wang et al.[82] investigated how an adaptive awareness system for shared virtual workspaces can be technically implemented and how its comprehensibility and usefulness can be evaluated by testers. The goal of this study was to present a system to reduce the information load of digital collaboration. However, this study provides only weak evidence that the automatic adjustment of notification rules can be useful in virtual collaboration, because information load and information overload were not considered as outcomes.

The results of a study by Bergström et al.[83] suggest that applying the theoretical basis of the coordination of joint activities is a promising way to develop a contrasting perspective of the factors that allow teams to maintain control in escalating situations. In a simulation in this study, both lay and expert teams were confronted with an escalating emergency situation on a ship. A key finding of the work was that in such highly complex situations, information must be prioritized and filtered to avoid information overload.

Ferreira et al.[84] also aimed to address the problem of information overload in synchronous group work. The authors experimentally examined team performance in a brainstorming task under the conditions "without attention management," where one team member's ideas were sent directly to all the group members, and "with attention management," where team information was sent only when the team member was not currently working individually. The use of attention management resulted in better team

performance in terms of the number of ideas generated, although the generalizability to other types of team tasks is unclear.

Stich et al.[50] found that creating mindfulness toward colleagues can be helpful in reducing information overload, for example, inquiring about which communication channels colleagues prefer. The authors suggested that leaders should take responsibility for this collegial mindfulness. In meetings, it can be helpful to establish rules for the use of digital media, such as turning off notification signals during meetings[51].

4.3.2. Leadership

Only a few papers have reported suggestions for leaders to reduce information overload. For example, Becker[60] conducted interviews with 12 managers in the health care sector, and based on the results, the author suggested limiting organizational priorities, creating clarity about project responsibilities and decision-making, organizing fewer and better -structured meetings, and establishing guidelines for the use of technology.

Spagnoli et al.[85] reported that workaholism and authoritarian leadership were positively correlated with experienced technostress. Specifically, for employees who worked exclusively from home, authoritarian leadership strengthened the relationship between workaholism and technostress.

Based on her own experience as a trainer and coach, Mill[86] presented ideas and strategies for managers to introduce training and other measures to reduce work stressors related to information overload and ICT use and to promote a positive work culture. In her view, these strategies should include effective communication, training for employee development, coaching, mentoring, and good leadership and inspiration, which can all positively influence the work culture and, thus, lead to improved health and well-being.

4.3.3. Summary: level of tasks and processes

In general, measures for stress-optimized work design have been proposed for the area of tasks and processes. Information overload is often associated with other quantitative and qualitative stressors, such as time pressure, high workload, interruptions, or role ambiguity. Although the causal direction of these relationships is not clear, a reduction in the accompanying stressors seems to contribute to a reduction in perceived information overload or technostress. Similar to the personal level, many proposals at the task and process level include approaches to increase the competence of individuals in dealing with digital information technologies. Additional support services (IT support, supervision) are also seen as helpful. The establishment of common rules (etiquette in dealing with ICT) has been mentioned several times in the literature as a worthwhile approach to reduce information overload. At the team level, the establishment of situational awareness (attentiveness to the situation) and shared mental models have been suggested. In addition, assistance systems for filtering and prioritizing information have been mentioned as starting points for dealing with information overload. Recommendations regarding leadership remain relatively superficial; a supportive and constructive leadership style is considered favorable, whereas an authoritarian or destructive leadership style tends to be unfavorable with respect to technostress and information overload[74–86].

4.4. Level of the design of organizational processes

At the level of organizational process design, behavioral and action guidelines can be introduced to address information overload[87]. The strategic use of internal communication can reduce the risk of information overload[88]. However, corporate culture is also a relevant factor[89]. Organizations can influence the way information is distributed and ensure that employees receive only relevant, prioritized information. Policies and norms for ICT use, clear responsibilities, and structured workflows can all contribute to reducing information overload. Additionally, tools and systems should be designed to support both filtering and prioritization of information at the organizational level. Organizational training and continuous support for employees are crucial for helping them manage high volumes of information effectively. Finally, leadership and management practices that emphasize clarity, support, and structured communication further strengthen organizational

resilience against information overload[74–89].

Farhoomand and Drury (2002) interviewed 124 managers in different countries about their experiences and approaches to information overload. Among other things, the managers mentioned the following: 1) identifying the dimensions of information overload (extent, irrelevant information, time constraints, variety of information channels) to provide targeted support to affected employees; 2) providing better tools and techniques to process information from internal and external sources; and 3) ensuring flatter hierarchies in combination with intelligent IT within the organizational structure[90].

In a cross-sectional questionnaire study, Florkowski (2019) examined associations between organizational policies and technology-related stress experiences, uncertainty, and job satisfaction in managers from 169 human resources (HR) departments in the US. The managers highlighted the importance of expectation management in technology use in HR and recommended continuous adaptation of the organizational climate regarding flexibility, risk-taking, evidence-based experimentation, and support for innovation[91].

Gaudioso et al. (2017) tested a serial mediation model and showed the indirect effects of techno-invasion via work–family conflict and of techno-overload via distress and coping (adaptive vs. maladaptive) on exhaustion. They recommended eliminating maladaptive coping strategies, developing adaptive strategies, increasing awareness of technology use, removing barriers (training, work design, reward systems, peer pressure, technical support), avoiding e-mails outside working hours, and improving organizational culture[92].

Pfaffinger et al. (2020) suggested, based on interviews with 26 employees from different countries, a wide array of measures to reduce information overload: investing in IT security, structured communication, effective introduction of new technologies, developing new work concepts, clarifying expectations regarding flexibility, ensuring compliance with work regulations, implementing ergonomics in home offices, providing technical support, helpdesks, training for managers and employees. At the societal level, they also recommended participation, public training, high-speed Internet for mobile phones, regulating surveillance, protecting data rights, legal frameworks for work–life separation, and infrastructure support[93].

Soucek (2017) examined e-mail communication agreements in organizations and found that company-wide agreements were most common and helpful, particularly intra-departmental agreements. Stich et al. (2018) further recommended clear ICT guidelines, including blocking e-mail traffic outside work hours, shifting from e-mail to internal networks, and establishing anti-cyberbullying policies[94].

4.4.1.   Summary: level of design of organizational processes

Recommendations at this level overlap with those at the level of tasks and processes. Participatory development of policies, corporate culture regarding ICT use, technical assistance systems, and promotion of competence in digital technologies are emphasized[90–94].

4.5.   Information technology level

Media richness theory highlights that the appropriate choice of technology affects information transmission[95]. At this level, filters, algorithms that summarize or extract information, and automated monitoring tasks are relevant.

4.5.1.   Use of information and communication technology

Introducing new or changing ICT can be a stressor[96]. Technology richness should match the information type (face-to-face for complex relational info, e-mail for simple coordination)[97]. ICT can facilitate team processes, reduce errors, and improve workflow if properly implemented[98]. Filtering capabilities, tagging, context management, and semantic technologies are suggested to reduce information overload[99–101]. Semantic knowledge management systems allow automated text processing and efficient keyword searches to prevent overload, although direct evidence for reduced overload is limited[101].

Celi et al. (2014) proposed ten recommendations for medical data systems: automatic integration, historical data collection, diagnostic suggestions, machine learning, customization, data aggregation, best practice reporting, changeability, new data integration, and

prototype testing[102]. Heimdall, an R-based tool for extracting relevant patient information, has been functionally evaluated but not yet in practice[103]. Stress-sensitive IT systems should prioritize user needs and provide recommendations only when requested[104].

4.5.2.   Filter and decision support systems

Decision support systems with higher autonomy can reduce information load but may increase technostress and reduce intention to use if not carefully implemented[105]. Clinical decision support can improve performance in pediatric ICUs, but careful selection is necessary to avoid negative consequences[106,107].

4.5.3.   Algorithms for summarizing or extracting information

Algorithms can identify actions, required responses, and tasks within e-mails or summarize texts to facilitate comprehension[108,109].

4.5.4.   Automating monitoring tasks

Algorithms have been proposed for surveillance, IT security, and traffic monitoring to reduce unnecessary alerts[110–112]. Clinical applications such as HAIL improved nurses' response times to alarms without affecting other tasks, suggesting potential to reduce information overload[113]. Automated alarms can improve patient care if users are trained and systems are optimized to reduce false alarms[114].

4.5.5. Summary: use of information and communication technology

Technological solutions should prioritize user needs to minimize technostress. Recommended interventions include tagging, filters, decision support systems, text-summarizing algorithms, and automated monitoring, though empirical evaluation is limited. Ensuring autonomy and usability is key to avoid adding to information overload[95–114].

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5.   Discussion

Empirical research largely examines predictors and consequences of information overload. However, practical workplace interventions can be derived, focusing on reducing cognitive, time, and technostress burdens. Figure 3 summarizes key recommendations across the five levels[115].

5.1.   Summary of results across the five levels

Information design: studies focus on quality and quantity of information. In healthcare, visualization dashboards reduce cognitive load and improve situational awareness but direct evidence of reducing overload is limited. Well-designed electronic patient records also show benefits[116–119].

Implementation considerations: differences in professional experience, context, and individual capacity must be considered when introducing dashboards or ICT systems. Information processing differs according to work experience[120,121] and the information needs of different task areas[122]. Overall, few studies have examined interventions to prevent information overload at the level of information design. General recommendations for information design can be found in guidelines for display design or more broadly in software ergonomics.

A relatively large number of measures to reduce information overload relate to the personal level. These include managing e-mails and Internet use, personnel training, and coping strategies to mitigate negative effects of experienced information overload. Training approaches may involve software solutions and the development of competencies such as digital literacy, information literacy, media competence, and self- and time-management[123]. Recommendations at the individual level overlap with literacy as a technostress inhibitor[124]. Concrete training concepts are described in Moser et al. (2002) and in the "New Quality of Work" initiative[15]. However, methodologically robust evaluations

of these training approaches are largely absent. Existing evaluations have not assessed reductions in actual information overload. E-mail and Internet recommendations include negotiating and formulating clear organizational rules and individual strategies for e-mail management. Other approaches at the personal level involve creating active boundaries between work and leisure and improving time- and self-management.

At the task and process level, Piecha and Hacker (2020) developed numerous recommendations based on a multi-method research project. Empirical evaluation of these measures remains limited, with the exception of the online teamwork intervention STROTA (Ellwart et al., 2015), which reduced information overload in the intervention group. Promoting situational awareness is recommended for managing complex information, and filtering and prioritizing information is particularly relevant in complex decision-making situations[125,126]. Constructive and supportive leadership is discussed as a resource for coping with work-related stress, though concrete intervention programs for managers are lacking.

At the organizational level, interventions overlap with other levels because implementing software, developing human resources, and designing tasks and processes must fit the organization's overall strategy. Recommendations include training (Moser et al., 2002), provision of technical solutions, company agreements for digital communication, IT security, and technical support. Together with techno-inhibitors such as participation and support for innovation[124], these measures help mitigate negative effects of information overload and technostress.

At the information technology level, general guidance exists for selecting communication media depending on the task[97]. Algorithm-based approaches for filtering, extracting, and summarizing information are described, as is the automation of monitoring tasks. Many studies present conceptual recommendations and algorithms, but field studies quantifying effects on information overload using experimental designs are still scarce.

Implementation of structural preventive measures requires careful planning and participatory design (Rigotti et al., 2014). Ideally, all intervention levels should be considered together[127]. Redesigning organizational information flow, supported by technical assistance systems, also requires developing personal competencies. Recommendations for reducing perceived information overload should therefore be coordinated across levels. Interventions in information design and technology must be adapted to sector-specific requirements. No single solution fits all applications; an analysis of current stress points in each field should precede intervention development.

Contribution of this review

Previous reviews focused on psychological factors influencing information overload[14,15]. Antoni and Ellwart (2017) omitted technical measures entirely, while Eppler and Mengis (2004) included them but are nearly two decades old, highlighting the need for updated guidance.

A recent meta-analysis focuses narrowly on characteristics of information[15]; our review covers five levels of causes of information overload, emphasizing the social and organizational context of information processing.

Other reviews are field-specific (e.g., Khairat et al., 2018) and omit generalizable findings from other occupations.

5.2. *Strengths and limitations*

This review covers studies from 2000–2021, reflecting rapid digital technology changes. A systematic search was conducted following PRISMA standards[128], supplemented with searches in PSYNDEX Interventions, Rehadat, Arbeitssicherheit.de, and BAuA/VBG publications. Two independent raters assessed studies against inclusion/exclusion criteria. Heterogeneity prevented formal evidence grading, but references to validity and generalizability are included. Limiting the review to randomized controlled trials was infeasible. Overall, robust empirical evidence on effective interventions remains limited; many studies are based on experience or qualitative methods without causal inference. The review adopts Eppler and Mengis' (2004) framework, distinguishing interventions by information, person, tasks/processes, organizational processes, and ICT. Clear assignment to a single level was sometimes impossible; a socio-technical approach integrating measures across levels is recommended.

5.3.   Conclusion

The studies included in this review cover a wide range of possible approaches to preventing or mitigating information overload. Regarding concrete information, it is essential to clarify what information is actually relevant and to present it in a clear, adaptive manner. The studies describe a variety of methods for managing large amounts of information for individual employees, some of which have been implemented as concrete interventions. Structuring and clarifying team collaboration can also prevent information overload, and managers play a crucial role in this process. At the organizational level, decision-makers are responsible for selecting appropriate software, establishing transparent internal rules, and providing technological support to filter or extract relevant information[74–129].

It is notable that intervention studies evaluating specific tools or training programs rarely used a true control group design. Moreover, information overload itself has seldom been measured as an outcome; in many studies, performance or subjective satisfaction with a tool was measured instead. A considerable number of studies employed qualitative methods to investigate intervention needs or existing strategies for coping with information overload. While interviews with employees reveal what strategies are already in use, they do not provide clear evidence of their effectiveness or suitability as starting points for interventions[74–129].

Although the individual level has been the most frequently studied, findings related to systemic prevention including task characteristics, processes, organizational support, and technical resources are comparatively more robust than those for purely behavioral interventions. Over the past two decades, the literature has increasingly recognized the influence of external factors on information overload, in addition to training and coping measures at the individual level[129].

CAUSES, CONSEQUENCES, AND STRATEGIES TO DEAL WITH INFORMATION OVERLOAD: A SCOPING REVIEW

Leila Shahrzadi, Ali Mansouri, Mousa Alavi, Ahmad Shabani

1. Introduction

Information overload has become a major challenge in the digital age, where people are surrounded by huge amounts of information from various sources. The rapid development of technology and the expansion of social media platforms and online content production have led to a constant flow of information and unprecedented access to a large amount of information. Of course, the concern about information overload is as old as the information itself[1]. However, with the emergence of digital information in the late 20th century, this concern has become increasingly more[2].

The presence of a significant amount of information, along with time constraints and limited cognitive capacity to process it, can significantly restrict the ability to make accurate decisions. This happens when people fail to integrate all the information into their decision-making process. The result of this is known as information overload[3]. In this situation, it becomes difficult for people to filter and prioritize relevant information and ultimately it can lead to confusion and difficulty in remembering information. According to Klapp[4], the receiver cannot process information effectively without experiencing distraction, stress, error, or other negative consequences of slow processing.

The consequences of information overload are multifaceted and can have a profound effect on individuals both personally and professionally, affecting cognitive abilities[5], psychological well-being[6,7], physical health[8], functional capabilities[9,10], and social interactions. As a result, both those who provide information and those who seek it are now actively[8,11] pursuing solutions to this multifaceted dilemma[5].

The importance of this identification phenomenon has made it necessary to recognize the main factors and effective countermeasures mentioned in previous studies in the form of a comprehensive review. Although some previous review articles have examined various aspects of the impact of information overload and ways to cope with it, most of them focus on a specific field such as healthcare management[12,13,14], Accounting and Finance[15], business[16,17], and very few studies[3] examine this information dilemma, but the need for a more comprehensive and interdisciplinary understanding of the phenomenon of information overload is evident.

A scoping review that synthesizes and analyzes the existing evidence across multiple disciplines can help address several important gaps, including identifying research gaps that may have been overlooked in previous field-specific studies; integrating knowledge and insights from various fields to develop a more holistic understanding; contributing to the development of broader theoretical and conceptual frameworks; and informing practical solutions by identifying effective countermeasures and strategies that can be applied across different contexts. In this scoping review, we aim to summarize and analyze the evidence with the following objectives: I. To investigate and identify the existing literature regarding the causes and factors of information overload; II. To investigate and identify the existing literature regarding the consequences of information overload; and III. To investigate and identify the existing literature regarding the methods of preventing and coping with information overload.

By adopting an interdisciplinary approach, this study seeks to provide a more comprehensive understanding of the information overload phenomenon and contribute to the development of effective solutions to address this growing challenge in the digital age. This article is organized into seven key sections. The first part is the introduction, which defines the importance of the topic and the need for a complete and interdisciplinary evaluation of the existing literature. The second section describes the methodology used to identify, select, and analyze relevant studies. Section 3 presents the results in three main sections: causes and effective factors in information overload, consequences and effects of information overload, and strategies for preventing and dealing with information overload. The fourth section is a discussion that delves deeper into these three key areas, analyzes underlying mechanisms, and synthesizes findings. Section 5 is a conclusion that summarizes the main points of the review. The strengths and limitations of the current review are presented in Section 6, and suggestions to guide the focus of future studies in this area are presented in Section 7.

2. Material and methods

A scoping review was conducted to identify the existing literature on the causes, consequences and methods of prevention and coping with information overload. This study

was conducted using Arksey and O'Malley's[18] framework for scoping reviews, as described by Levac et al.[19]. The research process consists of five distinct stages: formulating the research question, identifying relevant studies, selecting appropriate studies, organizing the collected data, and summarizing and presenting the findings. Each stage plays a crucial role in ensuring the accuracy and validity of the research outcomes.

The process involved five distinct stages: formulating the research question, identifying relevant studies, selecting appropriate studies, organizing the collected data, and summarizing and presenting the findings. The scoping review method is ideal for investigating a wide topic using various research methods and addressing various research questions. This method enables a comprehensive analysis of the subject matter, offering a deep understanding of the studied topic[19] and provides a broad overview of the available evidence without synthesizing or analyzing the data in depth. Scoping reviews are exploratory and descriptive in nature[20]. The aim of a scoping review is to identify the breadth and depth of evidence, as opposed to the quality of evidence[21]. One of their main advantages is the ability to include different types of literature, not limited to research studies[22,23,24].

Whereas, a meta-synthesis method involves analyzing and synthesizing the findings of multiple qualitative studies on a specific topic to develop new interpretations or theories[25].

2.1.   *Data selection and criteria*

This scoping review aimed to investigate the causes, effects, and coping strategies for information overload in existing literature. To answer these questions, the researchers conducted a comprehensive search using electronic databases such as Scopus and Web of Science, PubMed, and Emerald. The inclusion criteria encompassed published and peer-reviewed original research articles, reviews, and meta-analyses, with no restrictions on study types. Only English-language studies with full-text availability were considered. This study encompassed all types of study designs, including quantitative, qualitative, and mixed methods, as long as they were pertinent to comprehending the causes, factors, consequences, preventive measures, and coping mechanisms for information overload.

2.2.   *Information sources and search strategy*

A comprehensive literature search was conducted from the inception of the databases to January 31, 2023. The final combination of search terms, derived from the research question and included (("information overload" OR "information load" OR "overload of information") AND (symptom* OR sign* OR indication* OR reason* OR cause* OR factor* OR affect* OR effect* OR solution* OR management OR reduce OR control OR prevent* OR reduction OR "coping Mechanism*" OR reaction* OR countermeasure* OR cure OR "coping with" OR "dealing with" OR combat OR factor* OR strategy*)) to four databases: PubMed, Scopus, Web of Science and Emerald. To ensure the accuracy of the search results, duplicate publications from different databases were eliminated. Additionally, the references of selected articles were reviewed to identify any additional relevant literature. The screening process involved assessing the titles and abstracts of the documents for their relevance to the topic using specific keywords. Studies that met the inclusion criteria were retrieved in full text for further evaluation, while those that did not meet the criteria were excluded. Furthermore, a thorough examination of the reference lists and hand-searching was conducted.

In line with the standard approach to conducting scoping reviews[18], a quality appraisal was not performed. The results of the search strategy and the selection process will be presented in the form of a flow diagram, following the PRISMA guidelines[26] (Fig. 1).

2.3.   *Data extraction*

Data were extracted from documents that met the criteria for inclusion in this study. To ensure accuracy and consistency, meticulous attention was given to the extraction and organization of the data. Microsoft Excel software was employed to facilitate this process, enabling efficient and systematic data entry. The variables extracted from the final set of

documents, a comprehensive overview of the various aspects investigated in this study are: Author(s), year of publication, country of origin, type of study and instrument, aim or purpose, situation and population, key findings, and theories utilized in the study; Causes of information overload; Consequences of information overload; Prevention methods, solutions, and coping strategies for dealing with information overload.

2.4. Data synthesis

To synthesize the data, we employed a combination of tabular methods and narrative integration[27]. The decision to adopt a narrative approach for data synthesis was driven by the diverse quality of the evidence included in our study. To summarize the data extracted from the included studies, we utilized tables, while a narrative was employed to elucidate the key findings derived from these tables.

3. Results

The initial search yielded 12,861 articles. To enhance the research, we also consulted seminal works and examined the bibliographies of resources identified during the screening process, which added 50 more articles to our collection. After eliminating duplicates and applying our exclusion criteria, we were left with 463 articles for thorough analysis. Out of these, 89 articles met our eligibility criteria and underwent a comprehensive review.

By adopting a comprehensive approach that encompassed multiple countries, methodologies, subject areas, and theoretical perspectives, these studies collectively contribute to a deeper understanding of the topics under investigation.

In addressing the research questions, we thoroughly analyzed the reviewed studies across three key dimensions: effective factors (Section 3.1), consequences (Section 3.2), and prevention methods, solutions, and coping strategies for dealing with information overload (Section 3.3). To enhance the categorization and gain a deeper understanding of each dimension, we drew inspiration from the work of Eppler & Mengis3. However, we made significant modifications and incorporated additional aspects based on the wealth of available data.

By examining the effective factors, consequences, and potential solutions, we hope to contribute to the development of strategies that can alleviate the burden of information overload and enhance productivity in today's information-driven world.

## 3.1. Causes and contributing factors to information overload

In various studies conducted across different disciplines and areas, numerous factors have been identified as the causes and influencers of information overload. In this particular study, an extensive review of available documents was conducted to extract these factors from the texts. Subsequently, these factors were categorized into five distinct aspects, namely: Personal factors, Information characteristics, Task and process parameters, Organizational parameters, and Information technology parameters, as outlined in Table 1.

3.1.1. Personal factors

Personal factors play a crucial role in contributing to information overerload, serving as the primary context for its occurrence. Weaknesses in various sub-aspects, such as cognitive factors, psychodynamic and behavioral factors, and demographic factors, amplify the influence of external factors and render individuals more susceptible to information overload.

Among these personal factors, limitations in information processing ability or capacity have been consistently identified as the primary factor in numerous studies[29,30,31,32,33]. Additionally, the level of motivation and individual attitudes towards task performance[31,34,35,36], as well as deficiencies in personal experiences and skills[31,34,37,11], particularly in searching, retrieving, and comprehending information[2,38,39], are considered significant factors contributing to this phenomenon.

24.01.2026
Temp: -3°C
Rain: 0 mm
Wind: 12.8 m/s
Cloud: 97%
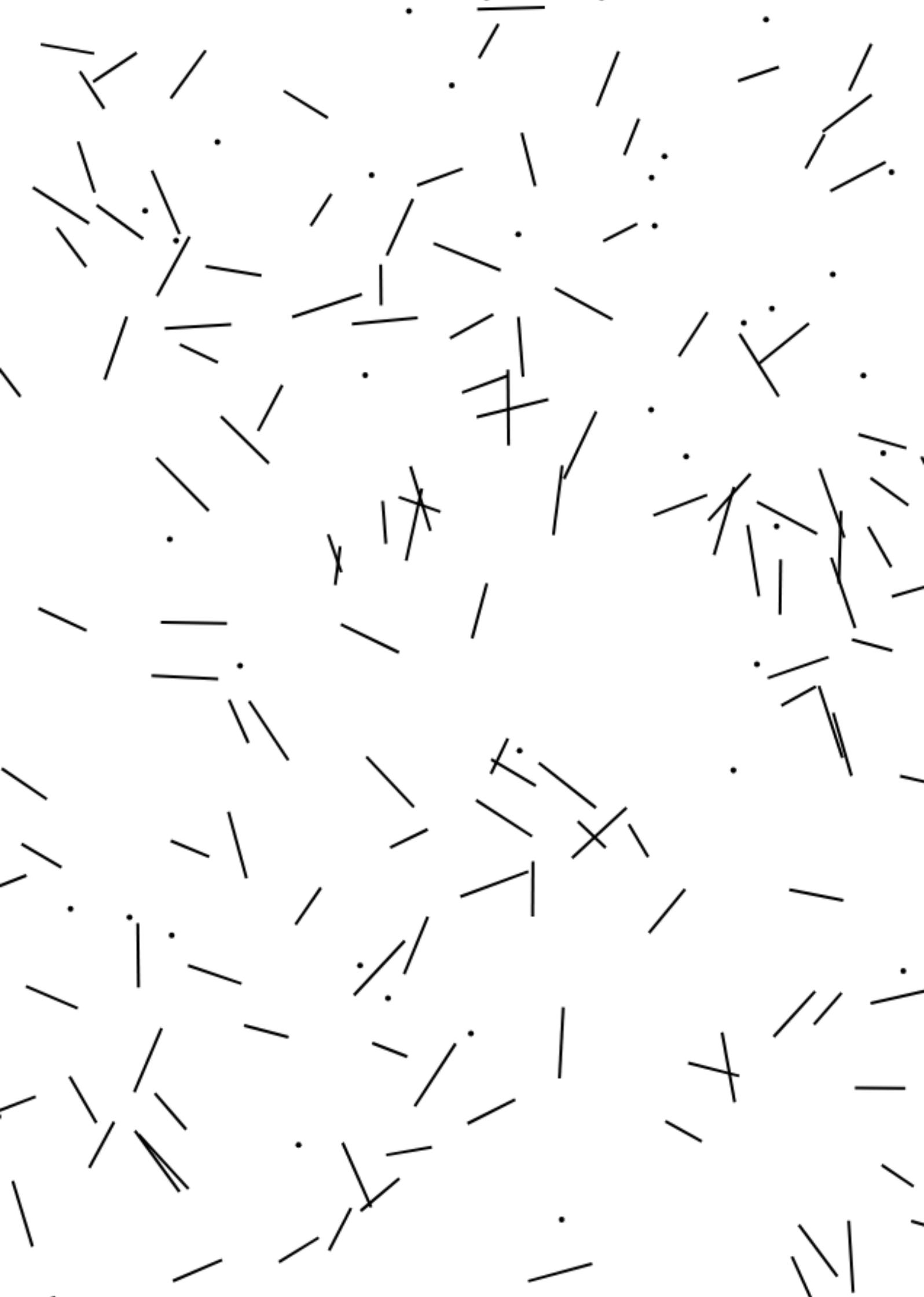
Furthermore, general characteristics such as age, gender, education level, and employment status are frequently cited as personal factors with a high impact on the occurrence of information overload[2,40,41,39,42].

3.1.2. Information characteristics

The second factor that contributes to information overload is the characteristics of the information itself and its sources. This refers to the nature of the information and where it comes from. Several studies[9,43,2,29,44,31,34,35,37,32,45,5,39] have highlighted that an increase in the quantity of information, including the number and variety of sources, contributes to information overload.

Furthermore, the quality of information also plays a significant role. Factors such as relevancy, validity, and half-life[31,41,37,32,33,39] can greatly impact the overload experienced. Additionally, the pollution of information[29,34,35,46,36,5] and the complexity of information[2,31,11,39] are significant factors contributing to information overload in this context.

3.1.3. Task and process parameters

Task and process parameters constitute the third aspect of the factors that contribute to information overload. It is undeniable that the nature, characteristics, and type of task assigned to an individual can exert a significant influence on the occurrence of i nformation overload. Various studies[31,34,37,32,47,36] have highlighted the impact of time limitations and time pressure on information overload. Additionally, the complexity of the work and its interdependency[30,31,36] have been identified as particularly influential factors in our review.

To enhance our understanding of the factors contributing to information overload, it is crucial to delve deeper into the realm of task and process parameters. The type of task assigned to an individual, along with its inherent characteristics, plays a pivotal role in determining the extent of information overload experienced. Time limitations and pressure have consistently emerged as key factors, as individuals are often required to process vast amounts of information within restricted timeframes. This heightened sense of urgency can exacerbate the burden of information overload.

3.1.4. Organizational parameters

One of the key factors contributing to information overload, as identified in the reviewed documents, is organizational parameters. These parameters encompass various aspects such as the organization's design, interpersonal communication practices, policies, procedures, standards, guidelines, and the culture of information sharing and decision-making. They play a crucial role in determining whether information overload occurs or not.

It is worth noting that the organization's information management is of utmost importance. Weaknesses in this area are particularly significant in our review[31,48].

3.1.5. Information technology parameters

The parameters associated with information technology constitute the fifth aspect contributing to the issue of information overload. Numerous studies[9,16,44,49] have highlighted the exchange of copious amounts of information within the work environment through email. Additionally, the continuous growth of information and communication technologies[9,29,44,37] and the excessive reliance on pull technology rather than push technology[2,16,31] have been identified as the primary factors contributing to information overload, as indicated in the reviewed literature.

3.2. Consequences of information overload

Information overload is a pervasive phenomenon that yields numerous consequences and effects. These complications manifest themselves at individual, organizational, and social levels, thereby warranting our attention. At the individual level, a plethora of physical, psychological, and cognitive complications have been extensively document-

ed in various literature, all of which can inflict significant harm on both organizational and social spheres. In this study, we have categorized the consequences and negative outcomes of information overload into four distinct groups: limited information search and retrieval strategies, Poor individual and organizational performance, Incorrect decision-making, and challenging personal situations.

By delving into the repercussions of information overload, we gain valuable insights into its far-reaching implications. Firstly, limited information search and retrieval strategies hinder individuals from effectively accessing and utilizing the vast amount of available information. This not only impedes their ability to make informed decisions but also restricts their potential for personal and professional growth.

Secondly, information overload adversely impacts individual and organizational performance. The overwhelming influx of information can overwhelm individuals, leading to decreased productivity, increased stress levels, and diminished job satisfaction. Consequently, organizations suffer from reduced efficiency, decreased innovation, and compromised overall performance.

Furthermore, the detrimental effects of information overload extend to decision-making processes. The sheer volume of information can overwhelm individuals, making it challenging to discern relevant and reliable data. As a result, decision-makers may make erroneous judgments, leading to suboptimal outcomes and potential setbacks for both individuals and organizations.

Lastly, information overload can create tough personal situations for individuals. The constant bombardment of information can lead to feelings of anxiety, confusion, and even burnout. These adverse psychological effects can significantly impact an i ndividual's well-being, relationships, and overall quality of life.

3.2.1. Consequences of information overload

One of the challenges posed by information overload is the reduction of systematic processing, leading to extra time, superficiality in information search, and lower search performance. This hampers the overall process of information search and retrieval. The reviewed literature highlights two major issues: information avoidance and the loss of relevant information[16,50,51,52,32,39]. These problems were frequently mentioned as the most significant harm caused by information overload.

3.2.2. Poor individual and organizational performance

One significant consequence of information overload is the decline in both individual and organizational performance. It leads to reduced work efficiency, productivity, and overall performance quality for individuals and organizations[9,16,29,53,54,44,34,55,17,5]. Moreover, handling increased information demands more time[9,34], which further exacerbates the negative effects.

3.2.3. Incorrect decision-making

The literature highlights several significant consequences associated with the influx of excessive information in the decision-making process. These consequences include a decline in the accuracy, quality, and effectiveness of both individual and organizational decisions[29,56,44,34,57,8,5]. Additionally, the introduction of excessive information can lead to potential paralysis and delays in decision-making[9,58,47].

3.2.4. Challenging personal situations

The reviewed studies have consistently highlighted several negative consequences associated with stress, confusion, tension, and cognitive strain[9,29,44,34,31,55,32,46,45,8,47,11,33]. Furthermore, mental illnesses such as depression and anxiety have also been identified as significant outcomes[9,29,6,22,58,55,46,33,59,39], Zhang et al., 2020. Additionally, tiredness has been consistently reported as a consequence[9,29,44,8], along with wasting time[9,29,44,8,16,34,55]. Stress, confusion, tension, cognitive strain[9,29,44,34,31,55,32,46,45,8,47,11,33], mental illnesses such as depression and anxiety[9,29,6,22,58,55,46,33,59,39], tiredness[9,29,44,8], and wasting time[9,44,34,31,55], were among the frequent negative consequences mentioned in the reviewed studies.

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3.3. Prevention methods, solutions, and coping strategies with information overload

As the abundance of information continues to expand across various fields, the need for effective prevention methods and coping strategies to combat information overload has become increasingly crucial. Reducing the occurrence of information overload can be achieved by eliminating factors that contribute to it and enhancing the capabilities of individuals and organizations to effectively manage this issue.

Extensive research has been conducted on this pervasive issue, resulting in the identification of numerous methods to prevent and manage information overload. In this study, we have categorized these solutions into seven distinct groups: personal factors, information characteristics, task and process parameters, organizational parameters, information technology parameters, information systems design parameters, and information search and retrieval strategies parameters.

3.3.1. Personal factors

Information literacy plays a crucial role in personal solutions to addressing the challenges of information overload[9,16,2,60,61,62,16,58,48,55,47,5]. Additionally, important is the development of personal information management (PIM) skills[9,63,9,2,16,64,49,58,8,36], enhancing information management abilities[9,63,2,60,49,48,8,5,65], prioritizing information effectively[44,8,47,66,65], and fostering self-efficacy in information-seeking[60,40,35,39,5]. Additionally, using the expertise of librarians and information professionals has been recognized as a valuable resource[60,40,16,41,67]. At the individual level, significant emphasis is placed on training and developing capabilities and abilities to effectively prevent and address information overload.

3.3.2. Information characteristics

Enhancing the visualization of information[30,34,67,66], improving the quality of information[68,38,69], and personalizing information[9,60,70] stand out as crucial approaches when it comes to information features.

3.3.3. Task and process parameters

Standardizing operating procedures[34,45,47] and extending information processing time or reducing time pressure during task execution[60,34,47] are crucial solutions that hold significant importance in the task performance process.

3.3.4. Organizational parameters

Paying more attention to reducing the divergence between employees in organizations, by increasing face-to-face interactions[44,71], utilizing information management techniques[16,48], and enhancing users' technological proficiency[2,34], are three main solutions that have been extensively discussed in the field of organizational management.

3.3.5. Information systems designing parameters

In addressing the issue of information overload, a range of tools, techniques, and technologies have been recommended to effectively manage the influx of additional information for users. Among them, two have garnered significant attention in the existing literature: the utilization of intelligent agents for information filtering[9,2,71,16,72,55,47] and the implementation of personalized recommendation systems[2,73,68,74,14,75,76].

3.3.6. Information technology parameters

The adequate design of information systems has emerged as the most important factor in the prevention of information overload[2,58].

3.3.7. Information search and retrieval strategies parameters

Enhancing search and information retrieval skills is crucial in combating information overload. The implementation of information quality filtering strategies, as highlighted by various scholars[2,61,16,44,36,67,77,55,78,65,79], has garnered significant attention in the existing literature. The omission strategy[9,44,37,77,65] and the withdrawing strategy[9,8,80,79] have emerged as particularly noteworthy. Table 3 presents the most crucial solutions and coping strategies for dealing with information overload.

4. Diskussion

This scoping review sought to explore and analyze the causes, consequences, and strategies for addressing information overload across various disciplines. Numerous studies have highlighted the significance of acquiring and honing diverse skills, particularly personal information management, as well as various literacies, notably information literacy. While personal factors have received considerable attention, organizational factors have been largely overlooked in the existing literature. This gap in research is concerning, as organizations play a crucial role in shaping the information environment for their employees.

4.1. Results in the dimension of causes and effective factors

Various studies have employed different approaches to categorize the causes of information overload. For instance, Al-Kumaim et al.[9] have classified the factors into three categories: personal, technological, and environmental factors. Rajabzadeh et al.[81] have identified four groups of causes, including individuals, technology, organization, and specification of the information. In line with the study conducted by Eppler and Mengis[3], this research categorizes the causes into five groups: personal, information characteristics, task and process, organizational design, and information technology. It is crucial to note that regardless of the classification approach, all factors should be acknowledged as contributors to the occurrence of this problem. This study has identified several key factors contributing to this information problem. These factors include a notable surge in the number and diversity of information sources, the prevalence of low-quality and polluted information, time pressure or limited task execution opportunities, and the inherent limitations of the human capacity to information process.

In this study, like the study of Klausegger et al.[35] and Ozkan & Tolon[32], processing capacity has been identified as the most important factor, while available time is relatively less important than other dimensions[35,32].

Each person has a distinct information processing capacity or cognitive threshold. Recognizing and strengthening the various components of information processing capacity can significantly enhance an individual's ability to cope with the challenges posed by information overload. Moko et al.[82] have identified several subcomponents of information processing capacity, which encompass cognitive ability, cognitive style, required time, level of prior experience, personal skills, and personal motivation.

Each of the other factors identified as the causes of information overload somehow influences the increase in the amount of information and decrease in its quality, the complexity of tasks, time limitations, and the decrease in information processing capacity. Therefore, by enhancing the brain's processing capacity and exerting control over external influencing factors, one can effectively mitigate the experience of overload.

4.2. Results in the dimension of consequences

The consequences of information overload extend beyond a single dimension. This study delves into the multifaceted nature of these negative effects, shedding light on four distinct dimensions that require careful consideration: limited strategies for searching and retrieving information, poor individual and organizational performance, incorrect decision-making, and the emergence of challenging personal situations. Recognizing these dimensions is crucial for individuals and organizations to develop effective strategies to mitigate the adverse effects and optimize their information management practices.

This research has uncovered numerous significant adverse effects that must be consid-

25.01.2026
Temp: -2.4°C
Rain: 0 mm
Wind: 11.2 m/s
Cloud: 98%

26.01.2026
Temp: -2.1°C
Rain: 10.8 mm
Wind: 12.6 m/s
Cloud: 98%

27.01.2026
Temp: -0.7°C
Rain: 0 mm
Wind: 11.2 m/s
Cloud: 83%
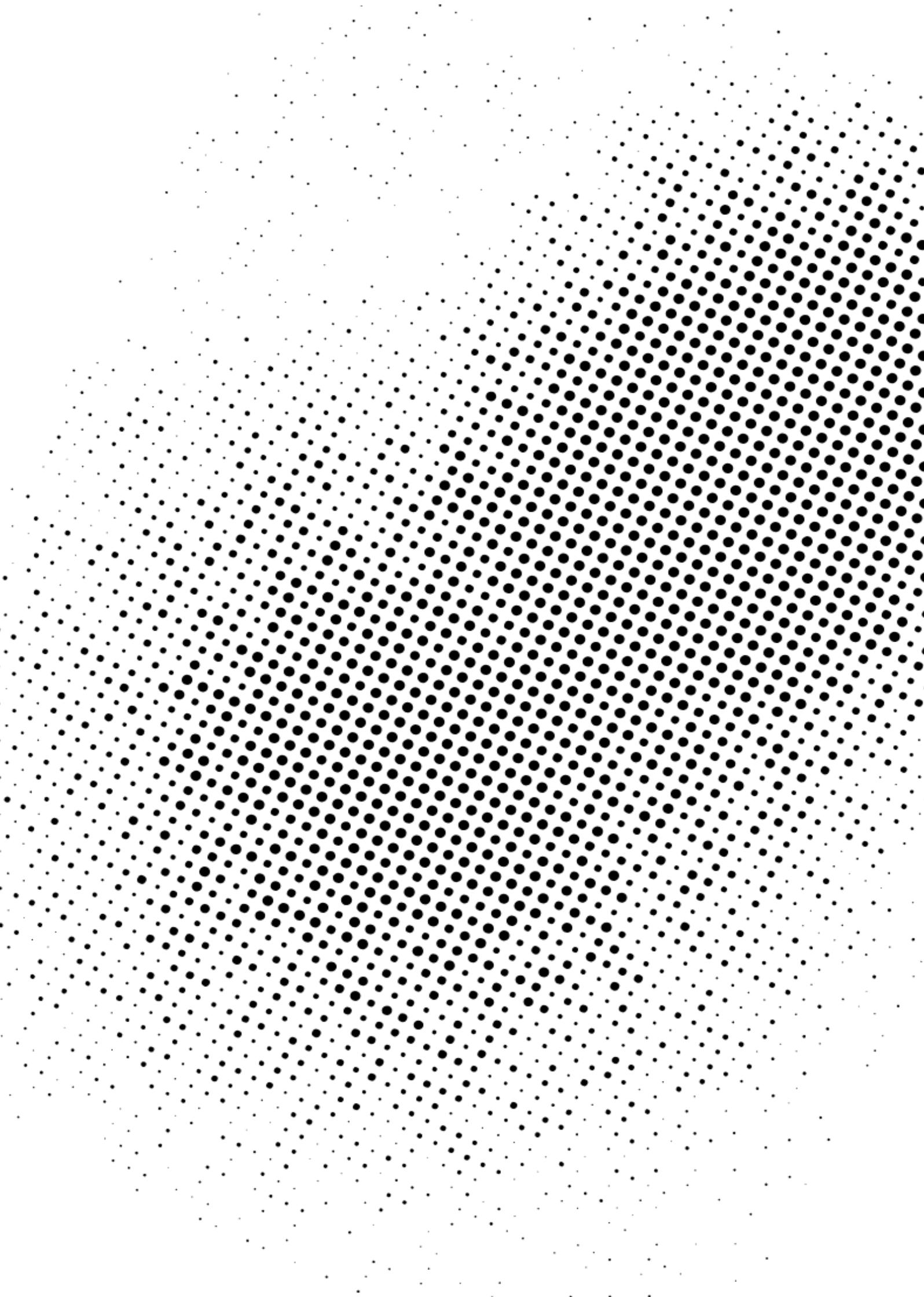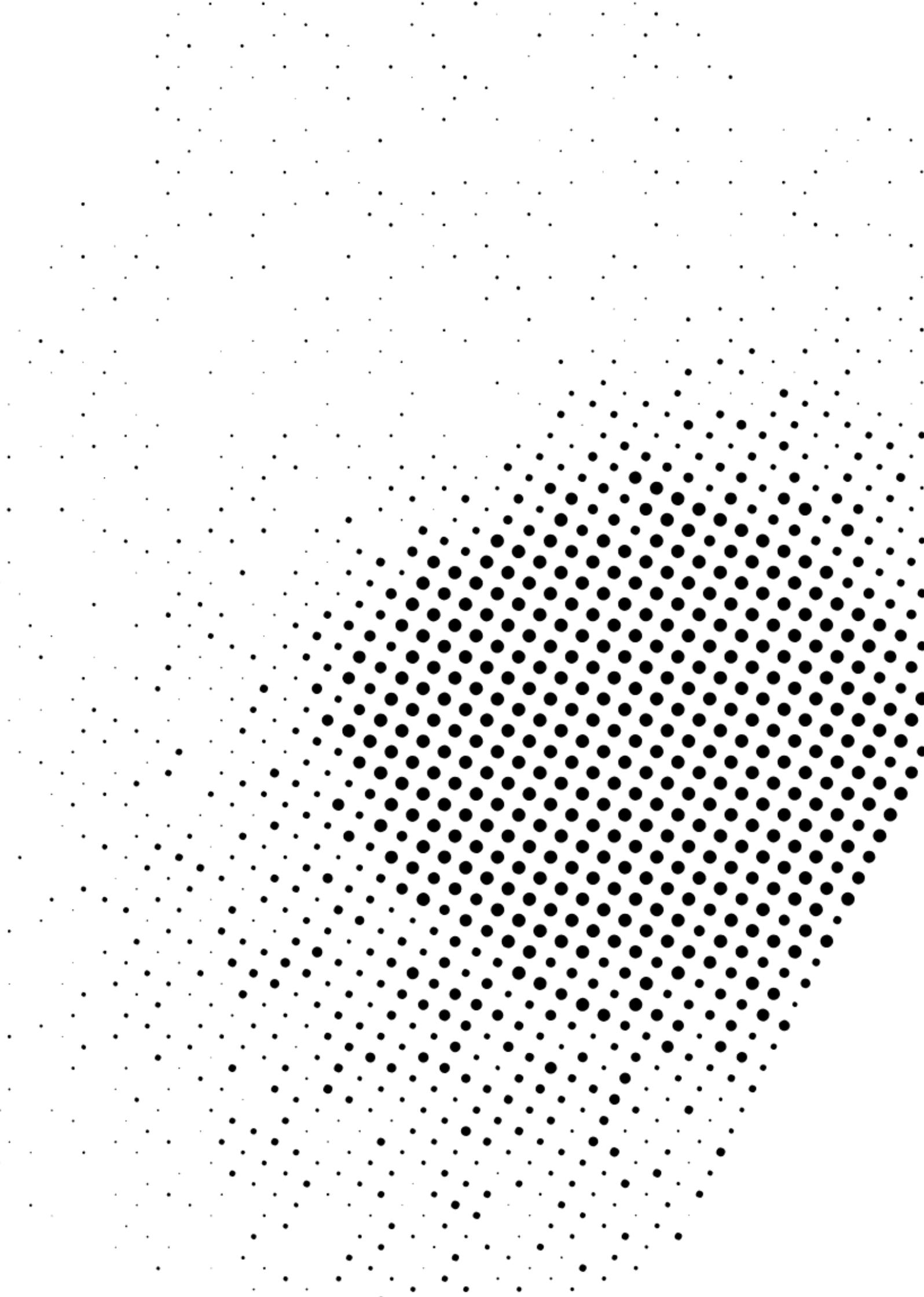
ered. The most prevalent effects include heightened stress levels, confusion, tension, cognitive strain, and even the potential development of mental illness. Other effects include reduced ability to learn, engaging in less thoughtful activities, not having a broader perspective, and ultimately, reduced job satisfaction. Information overload can also lead to decreased accuracy, quality, and effectiveness in decision-making, avoidance of information, and reduced productivity for individuals and organizations. The manifestation of any of these symptoms in an individual over an extended period can ultimately diminish their quality of life and hinder organizational performance. Acquiring the knowledge and skills to manage, prevent, and address information overload has emerged as an essential aspect of personal and professional development.

4.3. *Results in the dimension of prevention methods, solutions, and coping strategies*

The main objective of this study was to identify effective measures for preventing information overload and to propose viable solutions and coping mechanisms for individuals facing this challenge. To effectively manage information overload, it is essential to consider all contributing factors. Traditional cause-and-effect models are inadequate; instead, a cyclical structure and focus on interdependencies are crucial. Identifying these interdependencies early on and utilizing appropriate coping strategies is imperative. This study classifies coping strategies into seven levels: personal factors, information characteristics, task and process parameters, organizational parameters, information technology, information systems design, and information search and retrieval strategies parameters.

To combat information overload, prioritizing individual solutions is key. Training can effectively enhance personal resources to prevent information overload. Improving self-efficacy and acquiring various skills can enhance this capability.

At the personal level, educational interventions are vital in cultivating essential skills, such as Personal Information Management (PIM) and critical thinking. PIM involves the ability to collect, store, organize, and retrieve personal items, while critical thinking enables effective evaluation and analysis of information, distinguishing between factual and manipulated or inaccurate data. Furthermore, skills like email literacy are suggested as effective coping mechanisms.

A comprehensive understanding of information technology is achieved through the acquisition of various literacies, including media literacy, digital literacy, information literacy, and social media literacy. These literacies empower individuals to efficiently utilize high-quality information, prioritize it, and effectively manage the ever-growing volume of information available.

Enhancing the presentation of information, tailoring it to meet user needs, and utilizing visualization tools to enhance efficiency and accessibility are key strategies at the information characteristics level.

At the task and process level, implementing standardized procedures, extending task completion time, adjusting information flow structure, limiting the number of decision-making factors, and providing comprehensive, relevant, and up-to-date information are effective ways to reduce uncertainty. These measures can effectively alleviate information overload and enhance work processes.

By establishing standardized procedures, organizations can streamline operations and ensure consistency in processes. This not only enhances the overall quality of decision-making but also boosts individual performance within the organization. Allowing individuals to make informed decisions without time constraints fosters accurate and effective results, as it eliminates feelings of haste and pressure.

At the organizational level, it is imperative for the organization to prioritize the establishment of a robust technological infrastructure, provide cultural and educational support, develop research and technology policies, and create tools, facilities, and environmental conditions that mitigate information overload. Enhancing organizational design through the implementation of improved standards, establishing common procedures and rules, fostering a culture of information sharing, utilizing effective information management techniques, and eliminating barriers to efficient information utilization are critical strategies for achieving organizational success. Furthermore, fostering an environment that encourages regular face-to-face interactions, promotes a cooperative atmosphere

conducive to teamwork and knowledge sharing, is essential for organizational growth and development.

To effectively prevent and manage information overload, organizations can enhance individuals' information management skills, improve technology proficiency, involve users in system design, offer research and consulting courses, and consider hiring additional personnel to handle the workload.

In the realm of information technology, numerous effective strategies have been proposed to combat the issue of information overload. These strategies encompass a diverse array of tools and techniques aimed at streamlining the process of information consumption. For instance, filter agents, automatic summarizers, and visualization algorithms have emerged as potential solutions to this pervasive problem. Additionally, the utilization of text mining, data mining technologies, Web2.0 technologies, and interactive dashboards is highly recommended.

By leveraging these tools and techniques, individuals can effectively navigate the vast expanse of information available to them, extract valuable insights, and ultimately make well-informed decisions. Intelligent information management systems play a crucial role in simplifying the prioritization of information and providing users with useful filters. Decision support systems (DSS) serve as a prime example of intelligent systems that condense a plethora of options into a manageable set. Integrating NLP systems into the workflow allows for the utilization of artificial intelligence capabilities in search operations.

Through the use of automatic scanning, semantic filtering, and alerting mechanisms, users are empowered to navigate through the overwhelming influx of data with ease. Push technology serves as an extension of search agents and information filtering systems, delivering carefully curated and refined input directly to the user.

Poorly structured and ambiguous information results in information overload. To tackle information overload, the role of system design is crucial as it enables the creation of an effective filtering and management system for handling vast amounts of information. This necessitates the involvement of information architects who explore innovative strategies to organize and establish meaningful connections between information, while considering user objectives and behavior.

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To cater to the diverse needs of users, organizations must ensure that their systems can enhance user satisfaction and overall usability by aligning information systems design with user preferences and expectations. Furthermore, enhancing website design is crucial in creating a positive user experience. In addition to these measures, the design of information guides and the implementation of dynamic profiles can greatly support personalization. On the other hand, dynamic profiles allow for customization and adjustment of content based on individual preferences, ensuring a more personalized and relevant user experience.

At the level of individual information-seeking behavior, individuals employ various cognitive and psychological coping strategies. These strategies include escape and avoidance, ignoring, selective attention, delegation, creative destruction, filtering, withdrawal, blocking, and queuing[19,67,78,79].

Savolainen claims that there are two main approaches to dealing with information overload. The first approach is filtering, which involves systematically removing irrelevant information from selected sources. The second approach is withdrawal, which involves limiting the number of information sources[79]. When implementing these strategies, it is important to adapt different mechanisms to individual conditions, situations, and needs to effectively deal with the overload problem and achieve more comprehensive results. It is important to note that these strategies are complementary and a combination of them should be used to effectively manage information overload.

Conclusion

The main objective of this study was to identify effective measures for preventing information overload and to propose viable solutions and coping mechanisms for individuals facing this challenge. To effectively manage information overload, it is essential to consider all contributing factors. Traditional cause-and-effect models are inadequate; instead, a cyclical structure and focus on interdependencies are crucial3. Identifying these interdependencies early on and utilizing appropriate coping strategies is
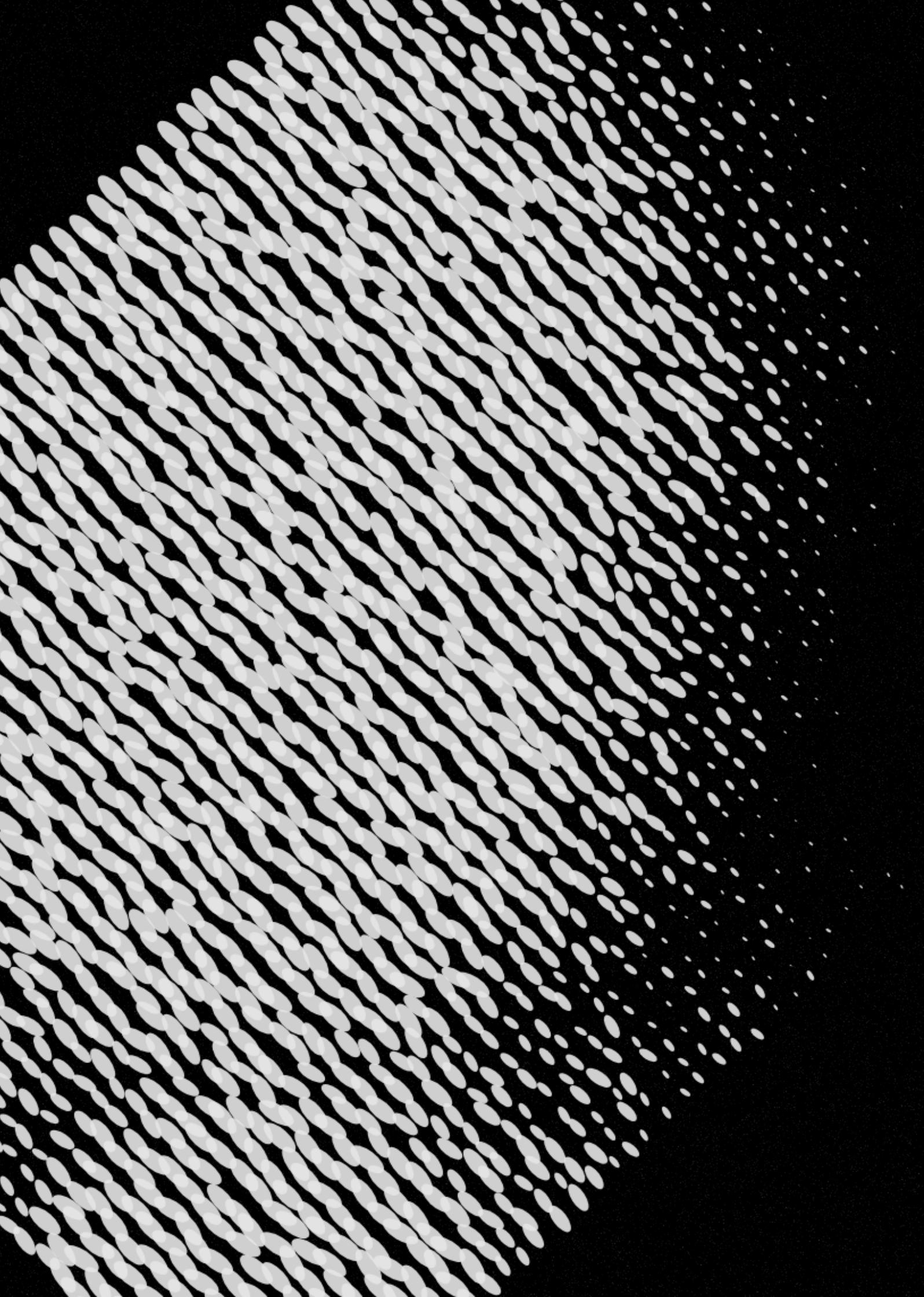
30.01.2026
Temp: 1.9°C
Rain: 0.9 mm
Wind: 17.7 m/s
Cloud: 99%
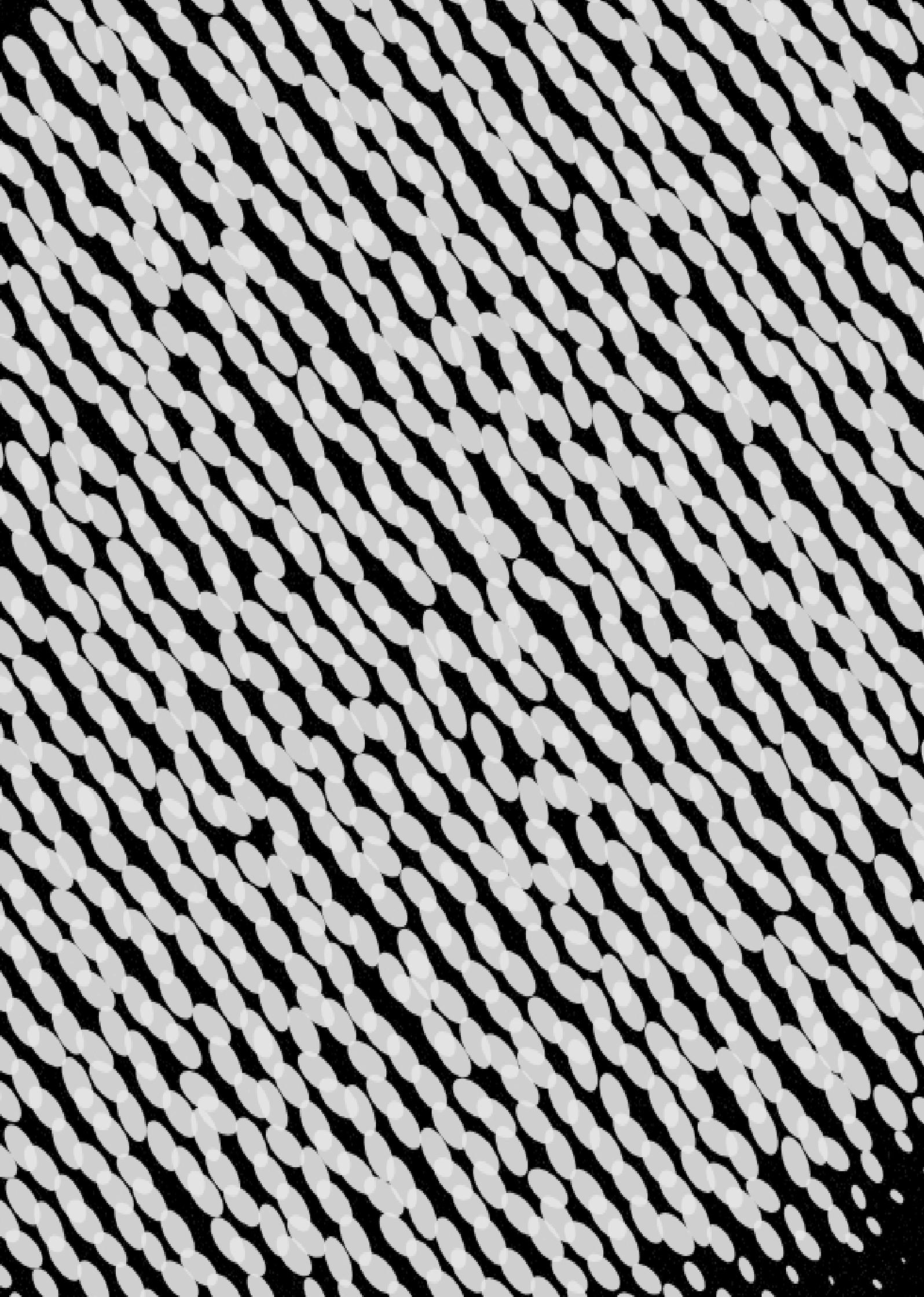
imperative[83]. This study classifies coping strategies into seven levels: personal factors, information characteristics, task and process parameters, organizational parameters, information technology, information systems design, and information search and retrieval strategies parameters. To combat information overload, prioritizing individual solutions is key[84]. Training can effectively enhance personal resources to prevent information overload[85]. Improving self-efficacy and acquiring various skills can enhance this capability. At the personal level, educational interventions are vital in cultivating essential skills, such as Personal Information Management (PIM) and critical thinking. PIM involves the ability to collect, store, organize, and retrieve personal items, while critical thinking enables effective evaluation and analysis of information, distinguishing between factual and manipulated or inaccurate data. Furthermore, skills like email literacy are suggested as effective coping mechanisms.

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By establishing standardized procedures, organizations can streamline operations and ensure consistency in processes. This not only enhances the overall quality of decision-making but also boosts individual performance within the organization. Allowing individuals to make informed decisions without time constraints fosters accurate and effective results, as it eliminates feelings of haste and pressure.

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To effectively prevent and manage information overload, organizations can enhance individuals' information management skills, improve technology proficiency, involve users in system design, offer research and consulting courses, and consider hiring additional personnel to handle the workload.

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By leveraging these tools and techniques, individuals can effectively navigate the vast expanse of information available to them, extract valuable insights, and ultimately make well-informed decisions. Intelligent information management systems play a crucial role in simplifying the prioritization of information and providing users with useful filters. Decision support systems (DSS) serve as a prime example of intelligent systems that condense a plethora of options into a manageable set. Integrating NLP systems into the workflow allows for the utilization of artificial intelligence capabilities in search operations. Through the use of automatic scanning, semantic filtering, and alerting mechanisms, users are empowered to navigate through the overwhelming influx of data with ease. Push technology serves as an extension of search agents and information filtering

systems, delivering carefully curated and refined input directly to the user.

Poorly structured and ambiguous information results in information overload. To tackle information overload, the role of system design is crucial as it enables the creation of an effective filtering and management system for handling vast amounts of information. This necessitates the involvement of information architects who explore innovative strategies to organize and establish meaningful connections between information, while considering user objectives and behavior[86].

To cater to the diverse needs of users, organizations must ensure that their systems can enhance user satisfaction and overall usability by aligning information systems design with user preferences and expectations. Furthermore, enhancing website design is crucial in creating a positive user experience. In addition to these measures, the design of information guides and the implementation of dynamic profiles can greatly support personalization. On the other hand, dynamic profiles allow for customization and adjustment of content based on individual preferences, ensuring a more personalized and relevant user experience.

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Savolainen claims that there are two main approaches to dealing with information overload. The first approach is filtering, which involves systematically removing irrelevant information from selected sources. The second approach is withdrawal, which involves limiting the number of information sources[71]. When implementing these strategies, it is important to adapt different mechanisms to individual conditions, situations, and needs to effectively deal with the overload problem and achieve more comprehensive results. It is important to note that these strategies are complementary and a combination of them should be used to effectively manage information overload.

DIGITAL OVERLOAD WARNINGS - "THE RIGHT AMOUNT OF SHAME"?

Aarathi Prasad and Asia Quinones

1. Introduction

Smartphones have increasingly become an integral part in people's daily lives, allowing them to manage activities[46], keep track of health and wellness[15] and also stay connected with family and friends[16]. However, the media is rife with articles regarding smartphone addiction and how digital overload may be harming users, especially young adults[43,44]. In this paper, we use the term digital overload to indicate the phenomenon where people are constantly using their smartphones, computers and tablets to obtain immediate access to messages from their loved ones, news updates and information from hundreds of networked apps. Researchers have shown that digital overload can lead to stress, anxiety, depression and lack of sleep, especially in undergraduate students[6, 10]. As a response to the negative backlash about digital overload, Apple and Google released ScreenTime and Digital Wellbeing on iOS and Android devices to help users make informed decisions about their smartphone app usage[29]. For example, the ScreenTime app feature allows iOS users to set a specific allotted time of usage per app[49]. When the timer is up, iOS shows a warning and temporarily blocks the user from returning to the app. ScreenTime also presents weekly reports about the users' overall app usage including apps opened and websites visited while analyzing how they use their device. Researchers have shown that nudging users about the time they spent on their devices helps them manage their smartphone use[34] so it is possible that ScreenTime may help users reduce their digital overload. However, we expect that reminding users about their digital overload may have a negative effect, especially in undergraduate students, who are avid users of smartphones[2] and may also be struggling with mental health issues such as anxiety and de- pression[1]. We wanted to understand whether digital overload warnings were effective in helping undergraduate students reduce their screen time, without adding to their mental health burden.

We conducted a survey among undergraduate students to understand whether they use the ScreenTime feature on their iOS devices to manage app usage and if so, how the tool affected their emotions; we chose to focus on iOS users who use ScreenTime to manage their iPhone usage because iPhones were more popular than Android phones on our campus.

In this paper, we provide the following contributions. We present the survey questionnaire and findings from the survey we conducted with 230 undergradu- ates to understand the effect of digital overload warnings on their smartphone app usage behavior. Our explora- tory study revealed that participants mostly experienced negative emotions on receiving a warning they had exceeded the time allotted for an app and despite receiving the warn- ing, most participants went back to the app. However, we also discovered that most participants felt content after viewing the summary of their daily app usage and believed that ScreenTime helped them understand and in some cases, alter their app usage behavior. We also present a discussion on why participants may ignore digital overload warnings, and provide design recommendations for nudging techniques to motivate users to reduce screen time.

2. Background and related work

It is important for users to learn to control their smartphone use as smartphone overuse distracts users while at work, in class, or while driving[13, 35, 28, 3]. On the other hand, researchers also discovered that vague examples of problematic smartphone use provided by popular media have influenced people's notions of smartphone overuse, causing them to be overcome by negative emotions such as guilt even when they used their smartphones for a useful task[25].

Emotions have been defined as feelings, expressive behavior or a responsive state[19]. Scherer defined emotions as a sequence of events – feelings that a person experienc- es, action taken as an immediate reaction to the feeling such as crying, an appraisal to evaluate events that caused the feeling, communicate our feelings through facial expres- sions such as a smile or a hug when we are happy, and finally, the physical response in our body, such as rush of blood flow when we are angry[41]. Plutchuk identified that every emotion also has an oppo- site emotion, so he presented eight primary emotions with varying intensity on a wheel with the opposite emotions represent- ed on opposite sides of the wheel[37]. Stressors typically lead to increased negative emotions[11] and negative emo- tions have been shown to lead to problematic use of

smartphones, especially in young adults[5, 4]. On the other hand, the Broaden-and-Build theory of positive emotion posits that when people are likely to broaden their thoughts and action and bring about change when they experience positive emotions, even if only for a moment[12]. So in our survey, we wanted to understand both the negative and position emotions participants experienced when attempting to control digital overload. Researchers identified social media and communication as the most addictive apps for undergraduate students[8]. Lee et al. discovered that college students who spent more time on their phones daily, especially immediately after receiving a push notification, were more likely to be addicted to their smartphones[27]. A survey of 612 participants showed that a lack of self control and low willpower also contributed to digital overload[24]. Prior research showed that college stu- dents are drawn to smartphones when they experi- ence stress in their personal and academic lives[23,47] and also when they have low self-esteem and high anxiety levels[21]. Researchers have shown that digital overload also can lead to stress, anxiety, depression and lack of sleep, especially in undergraduate stu- dents[6]. Prior research shows that smartphone use increased anxiety, stress, and feelings of impatience in college students, even when their phone was not with them[10]. Additionally, Toma discovered that self-comparison on social media sites such as Facebook led to depression, especially among people with psycho-social problems[45]. Tools that track a user's device usage can be very useful, since it has been shown that users are often unable to quantify the time they spend using apps on devices[26]. A study conducted with an app usage tracking tool called ScreenLife revealed that personal tracking of device use is desirable for increasing produc- tivity, and controlling device use[40]. Prior research also shows that nudging users about the time they spent on their devices helps them control their device use[34]. However, is it enough to just track how long you spend on different applications to understand smartphone usage? Harwood et al. discovered that it was the nature of smartphone use, and not the extent of use, that affected stress and depression[20]. Mehrotra et al. conducted a study to understand the relationship between user's emotional state and their app usage[30]. Our survey is the first that we know of, that studies the effectiveness of digital overload warning tools and specifically, how they affect users' emotions.

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3.   *Research Methods*

We conducted a survey of 233 undergraduate students to understand whether they use the ScreenTime feature on their iOS devices to make informed decisions about their app usage and what emotions they experienced when using different aspects of the Screen-Time tool. In our work, we considered emotion as the first event in Scherer's emotion model, i.e., the feeling that a person experiences. We addressed the following research questions:

– How many undergraduate students are aware of and use digital overload tools availa- ble on their phones?

– What time limits do they select for daily use of social media, entertainment and games; we have anecdotal evidence that students consider apps in these three categories to be most distracting.

– What emotions do they feel when they use an app for which they set a daily time limit?

– What emotions do they feel when they see the warning that they have ex- ceeded the time set for an app?

– What action do they take as a response to the warning?

– How effective are digital overload warnings in changing users' smartphone usage behavior?

The survey was administered using the Qualtrics software. The study was approved by the college's institutional review board (IRB) and we recruited the participants through an email sent to all undergraduate students at our institution. All participants were incentiv- ized with a $5 Starbucks gift card for completing the survey, irrespective of whether they had used the ScreenTime tool on their phones. We only considered iOS users for the following reasons: iPhones were more popular on our campus than Android, and Screen-Time was available on all iPhones unlike Android's Digital Wellbeing – we excluded the 2 Android users from the 233 participants who responded to the survey. It is unclear whether we excluded users from poor socio-economic background by only considering iOS users; we did not collect demographic information because it was not relevant to our

research questions.

The survey included questions about the participants' ScreenTime usage, emotions they felt when using ScreenTime, such as using an app with a time limit, when receiving a warning about exceeding time limit, and when reviewing daily smartphone usage summary, actions they took as a response to the time limit warnings, and any changes in their smartphone usage behavior. The ques- tionnaire is included in the Appendix section at the end of this paper. The list of emotions included in the survey questions was compiled from public American Psychology Association test records and articles in psychology journals about emotions and moods[42, 14, 31].

4.   Findings

We coded and grouped the qualitative data into themes that we present below, as well as analyzed the quantitative data using independent t-tests. We classified emotions as positive and negative using Plutchik's wheel of emotions[37].

Familiarity of ScreenTime. Out of the 228 participants we considered, 206 were familiar with ScreenTime functionality, but only 37 participants used the ScreenTime tool on their iPhones.

Time limits for social media, entertainment and games. In the survey, we asked partici- pants to choose the time limits they set for three categories - social media, entertainment and games. Most participants were concerned more about the time they spent on social media than entertainment apps and games. Using independent t-tests, we discovered that participants who had chosen a time limit of less than or equal to 2 hours for daily social media app use were more likely to experience negative emotions when they saw a time out warning ($p < 0.05$).

Out of the 37 participants, 34 had set time limits for social media use; the mean time was 4.5 hours, median time 2 hours, with an interquartile range (IQR) of 5 hours. 31 participants set time limits for games; the mean time was 4.13 hours, the median time 1.5 hours with an IQR of 3 hours. 29 participants set time limits for entertainment; the mean time limit was 3.93 hours, the median time was 1 hour with an IQR of 7 hours.

Reasons for using social media, entertainment and gaming apps.

The participants used social media, entertainment and gaming apps when they were bored or as a way to relax when they were stressed or having a panic attack. For example, one participant said, "I distract myself from panic with games and humor." while another said, "I use games and social media mainly as a distraction for when I'm bored or am kinda stressed [and] when [I] don't want to do something."

Participants associated negative and positive emotions with smartphone apps. One participant said, "When it comes to playing games I feel relaxed and happy to take my mind off of things but social media apps tend to make me happy but cause me lots of anxiety." Another participant said "sometimes social media can be overwhelming and anxiety inducing." Social media apps also invoked positive emotions, for example one participant found that Instagram, "[provided them] great inspiration for art and cooking and lifestyle habits", while another found comfort in using social media apps.

Participant emotions when using smartphones with ScreenTime enabled. As shown in Figure 1a, participants mostly feel positive emotions, though many participants also reported feeling stressed, ashamed, unsatisfied, overwhelmed and anxious when using apps for which they had chosen a daily usage time limit. Participants' emotions were affected by their perception of their smartphone use.

Some participants were not worried about their smartphone use but wanted to track the time they spent using their phones; one participant said, "I set the limits, but I don't really care if I go over them. [It is] just a way for me to know how long Ive spent on my phone." Others were relieved after learning, from ScreenTime data, that they used their phone less than they expected; one participant said, "I feel more satisfied because I know that my free time is not wasted by using these apps and it feels relieving when I am spending less time attached to my device."

However, some participants considered their smartphone use as problematic and experi- enced emotions such as shame and guilt when they were on their phone. One participant said, "I enjoy using the apps I often limit, but I feel guilty about using them, or almost ashamed". Another said, "I know I should be doing better things with my time, but the allure of social media is often difficult to overcome."

31.01.2026
Temp: 4.7°C
Rain: 1.2 mm
Wind: 25.7 m/s
Cloud: 100%
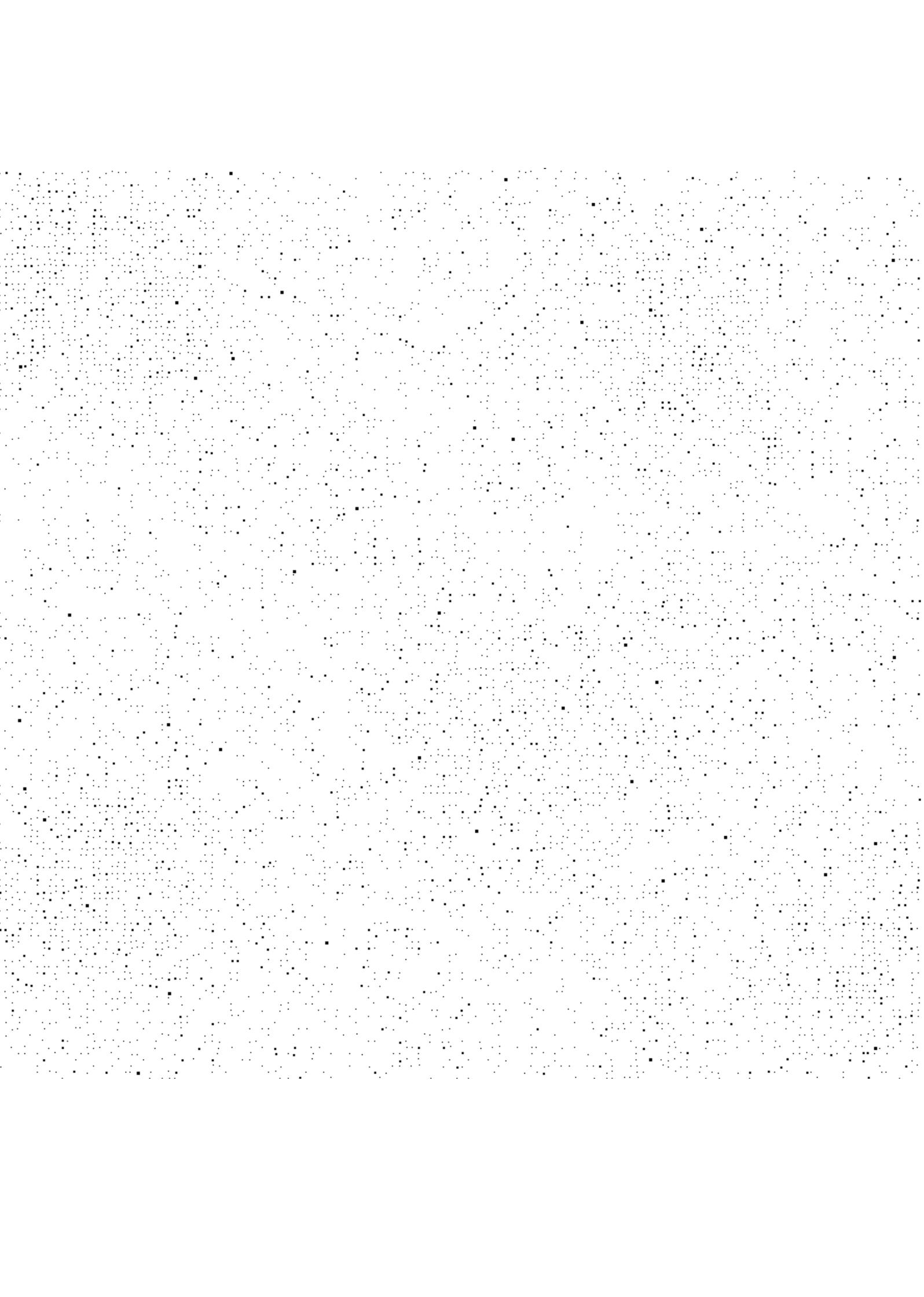
01.02.2026
Temp: 5.5°C
Rain: 1.2 mm
Wind: 17.6 m/s
Cloud: 97%

Other participants were able to use the apps without experiencing negative emotions, until they exceeded the time limit. One participant said, "I generally like using the app I set a time limit for (Instagram), but I know I spend too much time on it which makes me feel a little ashamed."

Participant emotions about exceeding time limit warnings. As shown in Figure 1b, participants experienced mostly negative emotions when receiving the warning that they have exceeded the time allotted for an app. Participants experienced positive emotions when they had chosen a time limit that they were comfortable with, while other reported feeling resentful, ashamed, unsatisfied, anxious, stressed, overwhelmed, sad, angry and worried when they realized that they had spent a significant time on certain apps that they were trying to reduce use of.

Some participants felt guilty for exceeding the allotted time limit; they asso- ciated the warnings with negative traits such as being addicted to their smart- phone, lacking self-control, procrastinating and being disconnected from their surroundings.

Some participants felt upset on seeing the warnings because they enjoyed using their smartphones. One participant said, "My phone and apps are a safety blanket and a distraction to what's going on around me and it gets upsetting that I don't have much to hide from." The other participant said, "I love being on my phone so when I get the notification I feel pretty sad."

Some participants experienced negative emotions based on the time of the day when they received the warnings, especially if the warnings appeared earlier in the day. One participant said, "I think I am always a bit surprised at what point in the day the timer alarms. Most days it is close to when I am going to bed, other days it is much earlier in the evening and that is when I feel a bit ashamed about how much I am on my phone." Another said, "I sometimes feel resentful that I have used all my time especially when it's early in the morning."

Some participants experienced positive emotions because they were able to stop using the phone when seeing the warning while others felt negative emotions for wanting to continue using the app despite the warning; one participant was "ashamed that I want to go over the limit". One participant said, "I feel content because I know that I won't be using my phone as much as I used to". while the other said, "I feel better knowing I am consciously controlling my screentime."

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Some participants felt negative emotions when receiving the time limit warn- ings but were able to reflect on the positive consequence of reducing smartphone use. One participant said, "I get annoyed sometimes BUT generally it's a good reminder to get the heck back to work" while another participant said, "The time warning makes me feel bad because it makes me aware of how much time I waste on the app. Ultimately I feel relieved though because I know that because of the time limit I am spending less time on the app." A third participant said, "I am sad because it shows that I've spent the day using the apps with all the time available to me, but I am glad that the timer helps me control the amount of time spent on my phone." Another participant was happy they did not have to monitor their own app usage, they said, "I'm vaguely resentful when the app locks because I want to keep using it, but I'm glad that the choice to use it has been (mostly) taken out of my hands, as I don't think my impulse control is very good."

Participants also liked the flexibility that ScreenTime provided, by not re- stricting their access to apps even after exceeding usage time limit. One par- ticipant realized that they could set high time limits to avoid seeing the digital overload warning. This participant said, "I feel positive feelings because the time limits I set are so high that it discourages me from getting anywhere close to that amount of time." Another participant also felt happy that ScreenTime did not lock them out of the app when they exceeded the time limit; this participant said, "I picked 'content' because the setting does not permanently lock me out of the app, so I do not worry when I can extend the time if needed."

Actions taken by participants as a response to the time limit warn- ing. Only 3 participants reported that they rarely went back to the app after seeing the warning. 13 participants said that they sometimes went back, 10 often went back and 4 always went back.

One participant felt better that ScreenTime made them consciously reduce the time spent on smartphone apps, but felt that they were missing out on the benefits provided by the apps, which made them want to use the app; this participant said, "It makes me feel better to know I'm spending less time on my phone, but I am still always wondering if someone has messaged me on one of the blocked apps and sometimes I ignore the time limit".

Some participants were unhappy that they continued using the apps despite getting the warning of exceeding the time limit; one participant said, "I picked "stressed" because I feel like I extend the time too often."

Participant emotions about their smartphone use, based on Screen- Time data. As shown in Figure 2a, participants experienced a mix of both positive and negative emotions (most participants felt content) when viewing a summary of their daily app usage, while others were unaffected by daily app usage summary; one participant said, "I dont care how long I spent in the apps".

Some participants noticed a decrease in their screen time and believed that the Screen-Time was indeed helping them reduce their smartphone usage. One participant said, "My time spent on my phone is slowly being reduced". Another participant found it useful that the ScreenTime allowed them to track the change in their smartphone app usage; they said, "I see that either improvements have been made or it shows what I need to work on". One participant said the daily app usage summary helped them realize how they used their smartphone during their leisure time; this participant said, "It makes me realize how much time I spent on my phone when I have a lot of free time in my day."

Participants experienced positive emotions when their smartphone app usage was low. One participant said, "When I see that I used it far less than average that day, I feel good that I focused on my school work and did not get distracted." Another participant was surprised by what the summary showed them, because it did not match their expectations of their own digital usage. "I'm content with how much I've used social media and since I didn't use it as much as I thought I did."

On the other hand, participants experienced negative emotions when they realized their smartphone usage was high. One participant said, "When it shows how much time you spend on your phone it seems sad." Two participants were angry at themselves after seeing the amount of time they spend on the phone; one participant said, "I don't want to be on my phone as much as I am" while the other participant said, "I get mad at myself for going over my limit.". One participant felt unsatisfied with how unproductive they were, "due to how much time I mindlessly spent on my phone."

Participants' change in smartphone usage behavior. 23 participants said their app usage behavior changed since they started using ScreenTime, while 5 said it had not changed. Some participants were able to reduce the overall time they used their phone. Some were able to control the urge to use their phone when it was not required, "I am not tempted to check my phone or pick it up every 20 minutes of the day" and another said, "I use my phone less when I am just waiting around". Some participants became more conscious about how often they would be distracted by their phone; one participant said, "Before using the screentime/ downtime feature I often got distracted because I would go to answer a text, but then autopilot to a time wasting app - the limit prevents me from continuing to spend time distracted." while another participant said, "[I am] more conscious of picking up the phone when I'm bored so I am able to put it down and find something else to do."

For some participants, their change in smartphone use was specific to social media apps. For example, one participant said, "I actually stopped being on social media for so many hours and now it has lessened to one or sometimes two." One participant deleted social media apps once they realized they spent a lot of time on them.

However, for most participants, their change in behavior came at the cost of negative emotions. One participant used their phone less on purpose because they were worried about seeing time limit warnings. Another participant experienced negative emotions when they used an app after seeing the warning, they said,

"I still override the lock from time to time, and I don't use my locked apps too much less, I just feel worse when I do use them." Another participant said that ScreenTime made them realize how much time they were "wasting" on using smartphones, when they could "put [that time] to better use".

On the other hand, some participants ended up using their smartphone more than they wanted to because they had not reached the time limit. One participant said, "Sometimes I am happy I didnt use all the screen time but sometimes i want to use more so when i get the notification it stresses me out or makes me annoyed that i used so much."

Overall, participants became aware of their app usage behavior better af- ter using ScreenTime; one participant said, "I have become more conscious of how much mind- less scrolling I do on Instagram and opening random things on Snapchat for example (I think most college kids can relate to this)".

Participants experience mixed emotions about the data provided by ScreenTime. One participant felt overwhelmed with the data while oth- ers found the data helpful in under- standing their device usage behavior. One participant said, "I notice that when I'm more stressed, I use it more, and vice versa."

One participant was satisfied with the amount of information provided by ScreenTime; this participant said, "I think more information would just make me feel worse honestly, this is about the right amount of shame."

Some participants wanted more detailed information about their app usage. For example, one participant said, "I wish you could breakdown the usage on specific apps, and how long the individual durations of use are per day.". Other participants wanted "a count- down [timer] and usage per app", "what times of the day I use them" and "what app I click on the most".

Two participants also had suggestions that were not related to time spent on apps; they wanted to know "how many times the phone is picked up" and "how much battery [the phone] uses and what that equates to in energy costs and environmental impacts."

5. *Discussion*

The goal of the ScreenTime feature was to help people make informed decisions about their digital overload, not to prevent people from going back to apps. But digital overload tools are expected to help people understand their smartphone app usage behavior and learn to reduce their screen time. Our survey revealed that users go back to the app despite getting a warning that they had exceeded the time limit, and that the warnings may make them feel negative emotions such as stress, dissatisfaction, shame and guilt. In this section, we discuss why people go back to apps even though they feel guilty when doing so, and explore design techniques could be used in order to encourage users to reduce their screen time, without inducing negative emotions.

5.1. Reasons for going back to apps

Many users reported feeling "addicted" to their devices causing them to feel inse- cure, stressed and anxious. This addiction could be the result of an attachment created between the individual and their smartphone, given how much users rely on their smart- phones now. Kim et al. studied whether avoidant attachment could predict smartphone addiction and concluded that avoidant attachment may lead to low self-esteem and anxiety in college students, which in turn may lead to smartphone addiction[21]. We plan to work with psychologists to ex- plore attachment theory further to understand why users go back to using their smartphones despite feeling negative emotions such as guilt and shame on being warned about digital overuse.

Some participants also mentioned that they used smartphones to escape from the stress in the "real world". This could be the result of social phobia among users. For example, Ding et al. discovered that social and communication apps are considered most addictive among college students[8]. Yen et al. showed that people with social phobia prefer to communicate with others via the Internet than in person[50]. It is important to take into consideration users struggling with social phobia when designing tools for digital overload; for example, users with social phobia will not benefit from tools that force users to interact with each other and not use their phones when in the presence of others, such as Lock n' LoL[22].

Another reason for digital overload could be the phenomenon called Fear of Missing Out (FoMo). Przybylski et al. define FoMO as the constant fear that others might be having rewarding experiences from which one is absent, which makes people stay continual- ly connected with what others are doing[38]. In our study, many participants reportedly went back to their apps even after receiving a warning that they exceeded the time limit allotted for the app, due to the fear of "missing out" on something while not using their phones. Digital overload tools such as ScreenTime are supposed to help reduce users' tendency to overuse apps but our survey revealed that reminders to stop using the app are only causing users to feel left out, making users go right back to the app. Pielot et al. demonstrated that users felt connected with others if they respond quickly to app notifications[36]. Designers might want to use positive reinforcement techniques that help users feel connected with others without being tempted to open an app, in order to help them reduce their screen time.

5.2. Techniques for behavior change

Digital overload tools, such as ScreenTime, are designed to help a user make informed decisions about the app usage. ScreenTime allows a user to choose a daily time limit for popular apps, and then warns the user when they exceed the time limit. ScreenTime does not force a user to stop using the app, but merely shows a warning screen, which a user can easily bypass to go back to the app if needed.

Some participants also pointed out how they were unaware of how long they had been using an app during the day; Okeke et al. developed a feedback mech- anism that allowed a user to see how long they used the app during the day and how many times they opened the app[34]. This nudging technique also "primes" a user for the warning once they exceed the time limit, and could potentially also reduce the negative emotions a user may experience when suddenly being shown the warning screen[32].

Instead of using a negative reinforcement technique by warning users to stop using apps when they exceed their time limits, digital overload tools could use a positive reinforce- ment technique such as rewarding a user for not using the app beyond the time limit; one participant said they went back to apps despite warnings because they were not reward- ed for quitting the app. Providing users with rewards, such as badges, have been shown to help change their behavior; for example, in mobile health apps, badges encouraged users to adopt a healthy lifestyle[39, 9].

Designers can also re-frame the warning message to provide a message that encourag- es the user to stop using the app. For example, the warning message could suggest other activities the user could do, such as take a walk, meditate, or listen to music, instead of going back to the app.

Participants often felt guilty and ashamed for spending a lot of time on popular apps, especially social media, because they believed the time they spent on these apps exceeded social expectations. Digital overload tools can provide actual data on how

others use the app; for example, the tools could give feedback based on the average time the users' friends, or people in their town, state or country spent on the app every day. However, as our survey showed, this could make users feel positive or negative depending on whether they spent less or more time on the apps than others. Participants often enjoyed using their smartphones; in some cases, participants considered smartphones as an escape from their stressful lives. These par- ticipants often experienced negative emotions when they saw the digital overload warnings. To prevent users from spiraling into negative emotions, designers can incorporate context -sensing to determine whether a user is already stressed or experiencing some negative emotion and take the outcome of the learning algo- rithm into account when deciding whether to warn users about digital overload; researchers have used smartphone data such as a user's app usage, call and sms statistics, and location traces to determine a user's mood and mental health state[48, 30, 18, 17].

6. *Limitations*

We conducted a survey to understand what emotions undergraduate students experi- ence when using digital overload tools. We are aware that survey responses may not reflect the actual emotions participants may feel when using the tool, but given our study was exploratory, our goal was to get a sense of the range of emotions participants may experience when using digital overload tools. In our
future studies, we plan to incorporate ecological momentary assessment (EMA) tech- niques to learn about users' actual emotions when using digital overload tools as well as conduct post-study interviews to better understand the reasons behind the emotions.
In our survey, we did not collect any personal information about the partici- pants such as gender or age because they were not pertinent to our research ques- tions. Other researchers have studied how age and gender affect digital overuse[7, 8, 33].
Our survey results are specific to the ScreenTime tool. We chose an existing digital overload tool instead of developing a new tool for the study because we did not want the users to experience additional negative emotions due to a steep learning curve. Finally, it is possible that participants' responses were affected by factors external to the study such as academic or relationship stress.

7. *Summery*

In this paper, we presented the findings from a survey conducted among under- graduate students to understand the effect of digital overload reminder tools. Our analysis revealed that participants mostly experienced negative emotions such as resentment, shame, and anxiety when the phone warned them that they had exceeded the time allotted for an app and most participants went back to the app despite receiving the warning. However, most participants were happy with their daily app usage and also found that ScreenTime had changed their app usage behavior. We also presented a discussion on why participants may ignore digital overload warnings to continue using apps, and provide design recommendations for nudging techniques to reduce screen time.
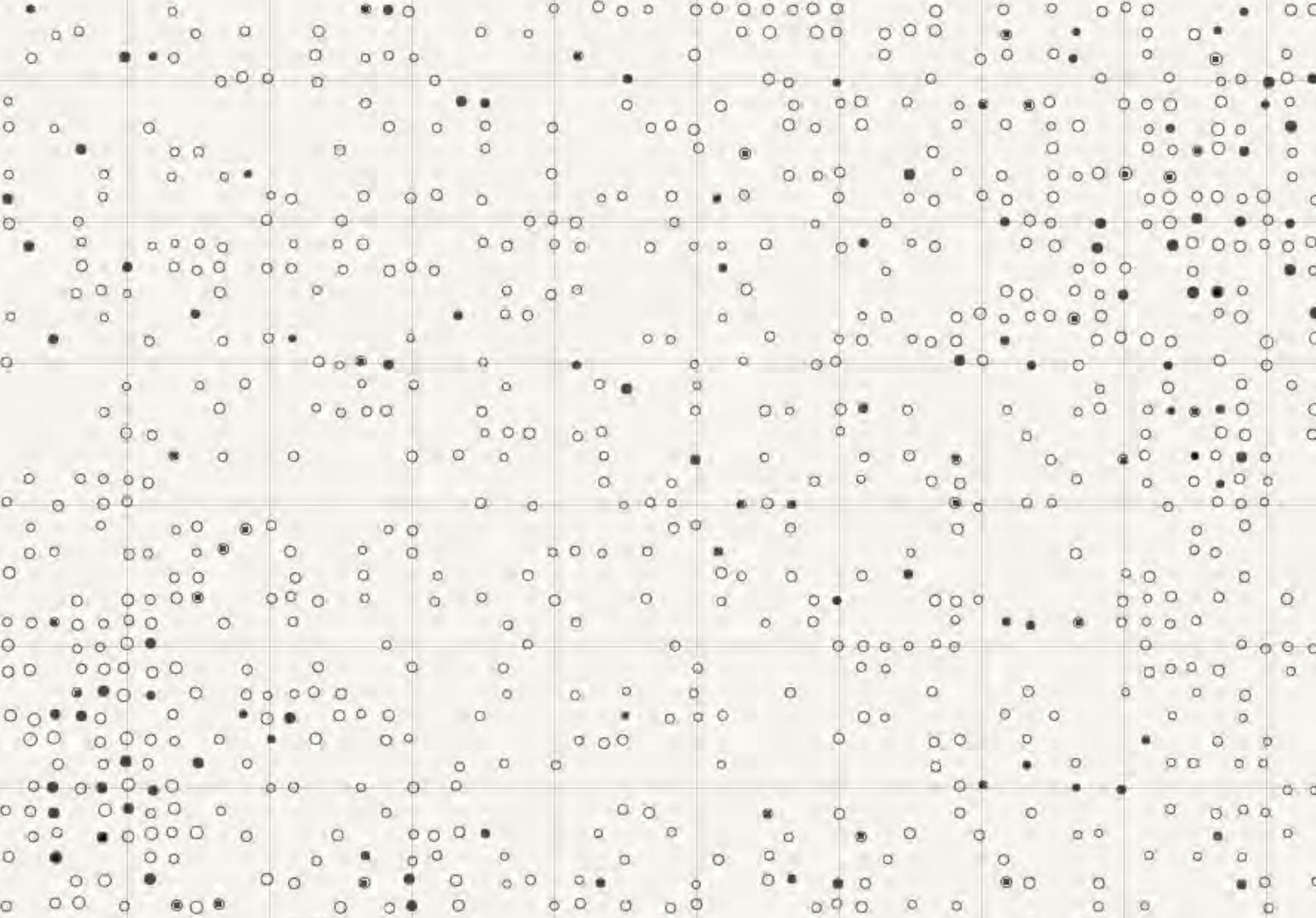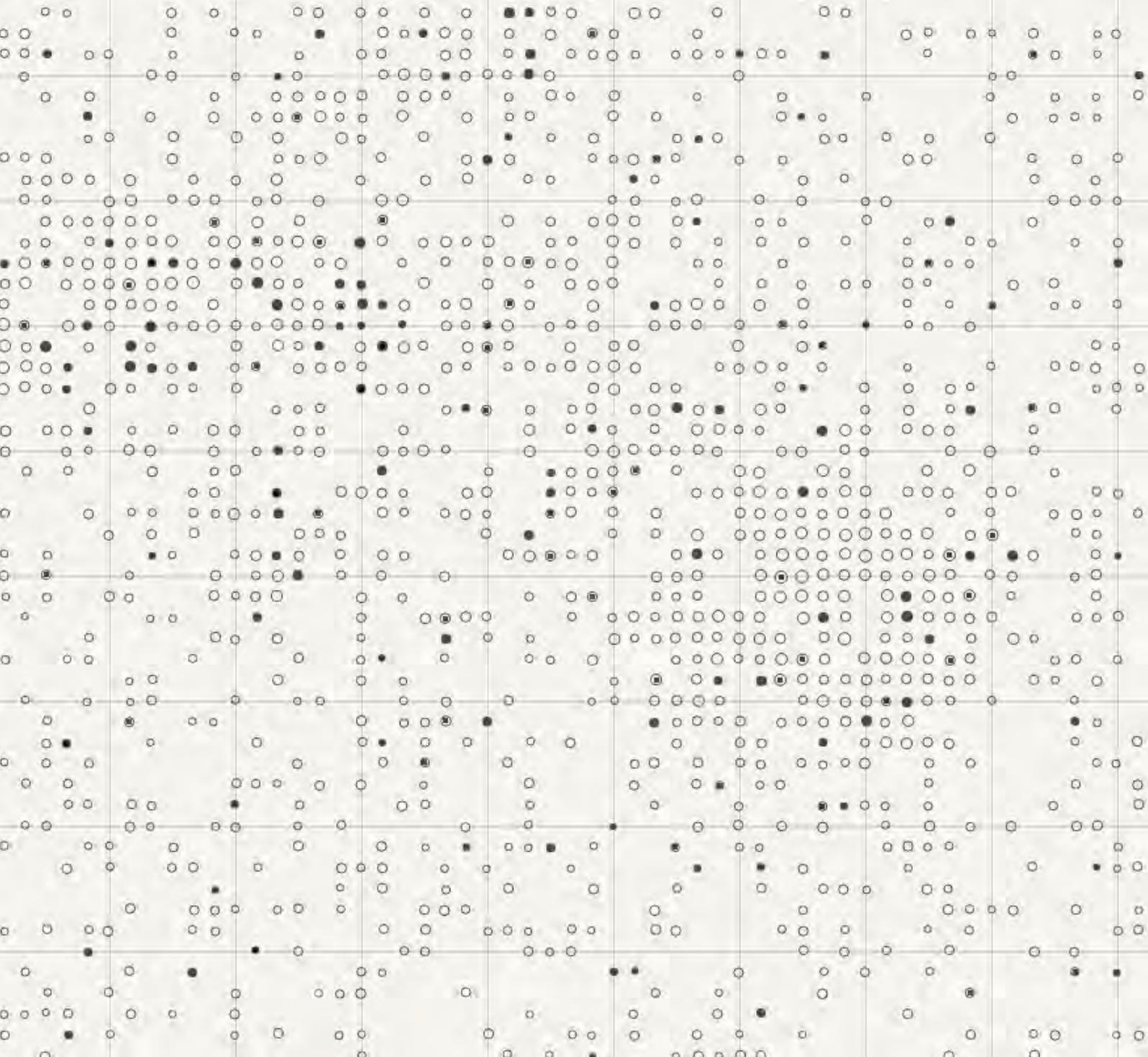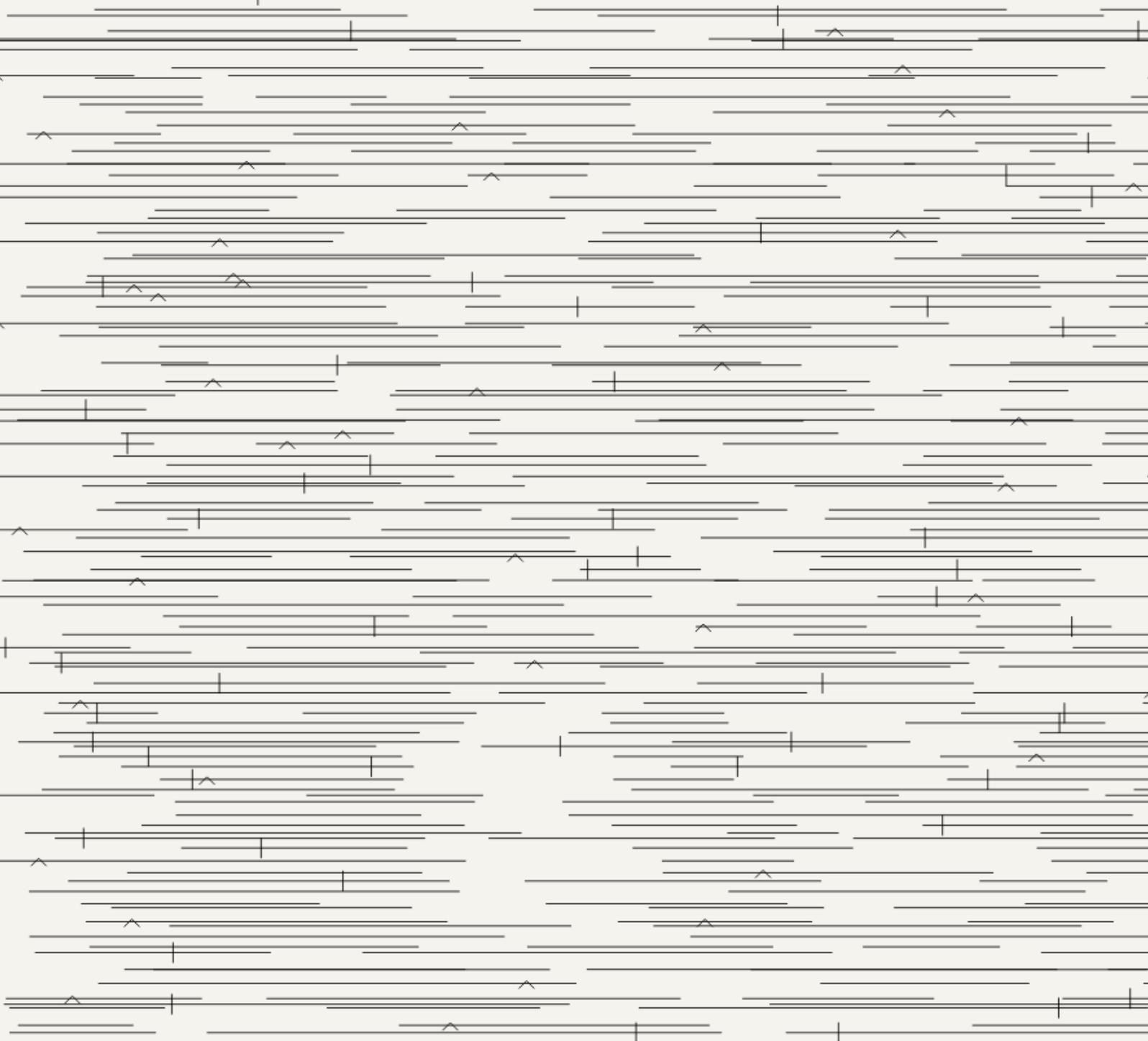
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