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Information Overload: A Concept Analysis

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Purpose

With the shift to an information-based society and to the decentralisation of information, information overload has attracted a growing interest in the computer and information science research communities. However, there is no clear understanding of the meaning of the term, and while there have been many proposed definitions, there is no consensus. The goal of this work was to define the concept of 'information overload' In order to do so, we performed a concept analysis using Rodgers' approach.

Methodology

We conducted a concept analysis using Rodgers' approach based on a corpus of documents published between 2010 and September 2020. We identified one surrogate for 'information overload', which is 'cognitive overload'. Our corpus of documents consisted of 151 documents for information overload and 10 for cognitive overload. All documents were from the fields of computer science and Information Science, and were retrieved from three databases: ACM Digital Library, SCOPUS, and LISA.

Findings

The themes identified from our concept analysis allowed us to extract the triggers, manifestations and consequences of information overload. We found triggers related to information characteristics, information need, the working environment, the cognitive abilities of individuals and the information environment. In terms of manifestations, we found that information overload manifests itself both emotionally and cognitively. The consequences of information overload were both internal and external. These findings allowed us to provide a definition of information overload.

Originality

Through our concept analysis, we were able to clarify the components of information overload and provide a definition of the concept.

Keywords: Information Overload; Concept Analysis; Cognitive Overload; Computer Science; Information Science; Information Retrieval; Information Technology

1. Introduction

With the rise in the amount of information available and ease of access, one phenomenon has taken an important place in users' information interaction experiences: information overload (IO). While researchers have extensively explored the concept,

there is no universally agreed upon definition. We found one popular definition for IO in Bawden et al. (1999), which defines IO as the result of so much useful and relevant information that it hinders rather than helps. In addition to not having a single definition, the term 'cognitive overload' is often interchangeably used to denote 'information overload' in computer science and information science. 'Cognitive overload' (CO) comes from cognitive psychology and stems from Cognitive Load Theory (CLT) (Sweller, 1988). Sweller explains in CLT that in order to maximise cognitive performance, we should not overload our working memory with information.

The concept of IO has seen a growing interest in recent years, and it has moved to the forefront of computer science (CS) and information science (IS) research. For example, in the ACM Digital Library, the keywords 'information overload' and 'cognitive overload' have seen a linear growth with 53 papers mentioning the word in 2003 against 254 in 2020[a].

A few phenomena can explain this growth: the shift from an industrial to an information-based economy (MacDonald et al., 2011), and the advent of social media (Koroleva et al., 2010). Social media created a fertile environment for the development of IO, whether through the diversity of content presented (Koltay, 2017), the increasing number of sources, or the push of irrelevant information and unwanted advertisements (Fu et al., 2020). In their conceptual model of IO in social networks, Koroleva et al. (2010) highlighted a positive correlation between the growing amount of connections and IO. The paper also noted an increase in users discontinuing their use of a service (Fu et al., 2020, Sasaki et al., 2015) as a coping mechanism.

In the early days of Information Retrieval (IR), a perceived cause of IO was the poor recall and precision of search engines as there was a lack of effective algorithms to access the growing body of digital information (Montebello, 1998). Nowadays, the problem of IO is still present but the challenges identified are more diverse, including a lack of information literacy, an increase in duplicate information, increase in redundant information, increase in the quantity of information, individual limitations, lack of prior knowledge, task complexity, lack of language proficiency, and time constraints (Bawden and Robinson, 2021, Hiltz and Plotnick, 2013).

To mitigate some of these challenges, advanced filtering and summarisation algorithms have been developed (Kaufhold et al., 2020). The aim of these algorithms is to reduce the amount of information individuals are facing online. In addition, thanks to the development in Artificial Intelligence and the improvements in recommender systems (Batmaz et al., 2019), there are new approaches to tackling the problem of IO, including an interest in developing emotion-based recommender systems which take into account the emotions that information elicits in individuals (Costa and Macedo, 2013, Pennington, 2016).

In the past, research in the field of IR considered IO as a problem (Montebello, 1998). IO was not researched as much in IR compared to other fields such as Organi-

[a]Number of occurrences in which the keywords appeared in the body of the publication

sation Science and Marketing, where extensive studies have been conducted (Eppler and Mengis, 2008). Researchers in these fields have offered several definitions of, and antecedents to, IO.

There is no consensus regarding the definition of IO, and the majority of work tackling IO in CS and IS lack rigour in defining the concept. With the growing amount and sources of information, IO became a crucial problem for our society. It favours the growth of misinformation and disinformation such as fake news (Gunaratne et al., 2020). It is also an obstacle for emergency services to filter out illegitimate information (Kaufhold et al., 2020). Furthermore, it impacts the mental health of the broader population (Matthes et al., 2020), leading people to drop out of their tasks and make bad decisions (Phillips-Wren and Adya, 2020).

Therefore, it is essential to establish a definition that highlights critical attributes of the concept, because a clear operationalisation will allow researchers to study it with greater rigour. In this paper, we applied a concept analysis (Foley and Davis, 2017) using Rodgers' approach (Rodgers, 1989), and we aimed to offer a clear definition of IO. Concept analysis is a method we borrowed from nursing science that provides a straightforward and reproducible clarification, as well as an explanation of, concepts (Tofthagen and Fagerstrøm, 2010).

The paper is organised as follows: we first introduce previous research around IO and why a concept analysis is necessary. Then, we present the methodology used and how we surveyed the papers. Subsequently, we present the findings through the different themes we extracted. Finally, we define IO and conclude our work.

2. Background

Various types of overloads have been presented in the literature and are closely associated with IO. Alongside IO, there is information anxiety, infobesity, and cognitive overload (Bawden and Robinson, 2009, Lauri and Virkus, 2018, Sabeeh and Ismail, 2013). Marques and Batista (2017) argued that the most recent research in IO should be classed as communication overload (Marques and Batista, 2017, Virkus et al., 2017), as it deals with the exchange of information and communication across the web among individuals and groups. These different terms which are interchangeably used with IO (Jackson and Farzaneh, 2012) highlight a lack of consensus on what is the concept of IO.

Researchers such as Sasaki et al. (2015) have attributed the first use of the term to Gross (1965) in the context of Organisation Science (Sasaki et al., 2015, Ndumu, 2020), Levy (2008) attributes it to Meier (1962) in the context of Urban Studies. However, we can trace back the first allusions to Biblical writers and Socrates (Ndumu, 2020). Diderot et al. (1755) predicted that as the centuries pass, the number of books will be so large that it will be as difficult to find the information in the books as trying to study the universe directly. In the 19th century, the neurologist Beard (1881) studied neurasthenia, a medical condition with symptoms of fatigue and anxiety. He was the first to link the propagation of information to the

problem of overload as he described the impact of the growing number of newspapers and magazines on readers in his book titled 'American nervousness, its causes and consequences: a supplement to nervous exhaustion (neurasthenia)'.

Later on, with the end of the Second World War, Bush (1945) became aware of IO and its development as scientific advancements were moving at a faster pace. He proposed developing a machine in which people can organise books and documents called the 'memex'. Bush can be considered the first to suggest IR systems as a way to solve one antecedent of IO: the quantity of information. While Miller and Meier (Levy, 2008, Virkus et al., 2017) might have been the first to look at parts of the elements that constitute IO today, we can consider Gross (1965) to be the first to coin the term of information overload and to give a formal description of the term, he highlights the limited cognition of humans, i.e. when they become overloaded with information, their decision-making suffers. Finally, it was Toffler (1970) who popularised the term 'information overload' in his book *Future Shock*.

Many attempts to define IO revert to Miller's experiment from 1956 (Miller, 1956) in which he shows the limits of humans' working memory. It is considered the first study to focus on IO (Virkus et al., 2017). Another popular definition used (Schroder et al., 1967) describes the consequences of IO as an inverted U-curve: the quantity of information increases until it reaches a point where its utility starts decreasing. Additionally, the paper linked IO and cognitive overload.

Bawden and Robinson (2021) have shown that while the nature of IO does not change and has been present throughout history, there have been new causes. We believe these various attempts to define IO require refreshing as they do not consider new causes; one new driving force is the decentralisation of information. Among the new causes of IO, there is an absence of gatekeepers who were in charge of filtering information and ensuring its quality (Koltay, 2017). In online information platforms such as social media, as the number of users increases, there is an increase in information due to the volume of messages exchanged (Chen et al., 2011) and a rise in sources of information, which makes it more challenging to control information quality (Fu et al., 2020, Rodriguez et al., 2014). It has been shown that both the growth of sources of information and increase in redundant information lead to IO (Chen et al., 2011, Jacobfeuerborn and Muraszkiewicz, 2013, Shrivastav and Hiltz, 2013).

With these new causes of IO come new consequences. For example, users are less likely to choose media with redundant information (Liang and Fu, 2017). Within disaster situations, the failure to filter information increases, and it becomes more challenging to extract valid information (Hiltz and Plotnick, 2013, Kaufhold et al., 2020, Keselman et al., 2010). In collaborative environments, an increasing amount of information means it is difficult to separate noise from relevant information (Zhang, 2018). For e-commerce, extensive product descriptions lead to worsened decision-making and less rational buying choices (Palma et al., n.d.). News reporting has become increasingly more difficult as noise can be generated on social media, and

it facilitates the propagation of fake news (Holton and Chyi, 2012, Kaufhold et al., 2020). The decentralisation of information in the case of news reporting and ease of access lead to high exposure to news, resulting in stress due to IO (Schmitt et al., 2018). Two coping strategies have been identified in relations to these new causes and consequences: filtering and withdrawal (Savolainen, 2007).

Many surrogates for IO are present in the literature (Whelan and Teigland, 2013). However, a common surrogate for IO is cognitive overload (CO). As previously mentioned, CO is not a term from information science, but rather from cognitive science, specifically Cognitive Load Theory. However, papers discussing IO often use both terms interchangeably (Jacobfeuerborn and Muraszkiewicz, 2013, Memmi, 2014), which leads to a potential lack of clarity. Therefore to better understand IO, we also chose to sample papers discussing CO.

The presented causes and consequences of IO make it necessary to provide a definition that considers all these aspects. In this work, we ask the following questions:

- **RQ1**: What is information overload?
- **RQ2**: What, if any is the difference between information overload and cognitive overload?

In order to answer these questions, we built a dataset based on the literature published between 2010 and September 2020. We have explained our methodology in the subsequent section.

3. Methodology

3.1. *Rodgers' approach to concept analysis*

Conceptual clarity is essential in academia as it allows researchers to understand the relevant and irrelevant attributes of concepts and isolate them for their studies. A concept can express the same idea in different words and can be influenced by the context in which it is used. Different appellations have been used for IO in computer science and information science, such as cognitive overload, choice overload, and infobesity, which has generated a lack of clarity and a poor understanding of the problem. Therefore, it is necessary to take on a direct and reproducible approach to comprehensively grasp the notion and develop a clear definition. In our work, we borrow a method from nursing science called concept analysis. Concept analysis is a methodological approach used to better understand and clarify concepts (Foley and Davis, 2017). It is the first step necessary to develop theories and a product that can be further tested. Fleming-May (2014) highlighted the potential of concept analysisto help information scientists establish the foundations on which concepts can be studied.

We chose the Rodgers (1989) approach to concept analysis in this study. It is inductive and offers more opportunities to develop a concept rather than extract definite conclusions. It is systematic and has clearly defined steps: the initial phase,

core analysis phase, and finally, the further development phase. Each step can be repeated and done in parallel.

During the **initial phase**, researchers need to choose the concept of interest and research areas. Since various terms can be associated with a specific concept, it is during the initial phase that these are identified. At this stage, the inclusion and exclusion criteria and the databases must be chosen. In our case, we were interested in defining IO within computer science and information science, so we selected databases that cover these fields.

During the **core analysis phase**, researchers identify patterns and extract the themes. This phase consists of reading all the literature identified in the previous step and extracting information to identify the patterns and main themes. Following Rodgers' approach, a researcher extracts surrogates, related terms, antecedents, attributes, and consequences (Table 1) (Tofthagen and Fagerstrøm, 2010).

Surrogate	What are the terms used interchangeably with the concept? (if any)
Related terms	What are the terms which share overlapping themes with the concept? (if any)
Antecedents	What are the events that lead to the concept?
Attributes	What are the characteristics of the concepts?
Consequences	What is the result of the concept?

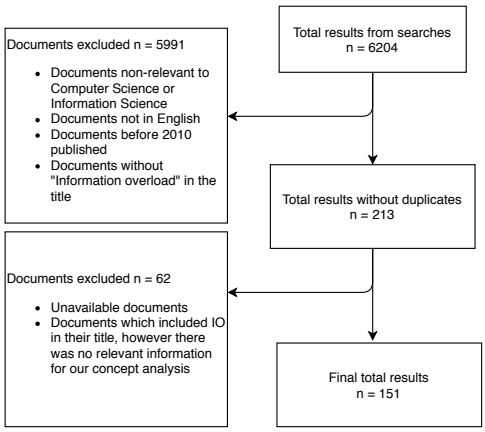
Table 1: Items to extract (Rodgers, 1989)

If relevant surrogates are identified, another round of reading is added to extract the same information for each surrogate. It is important to continue this phase until the data starts to repeat itself; this allows the researcher to identify the relevant attributes for the concept in the next phase.

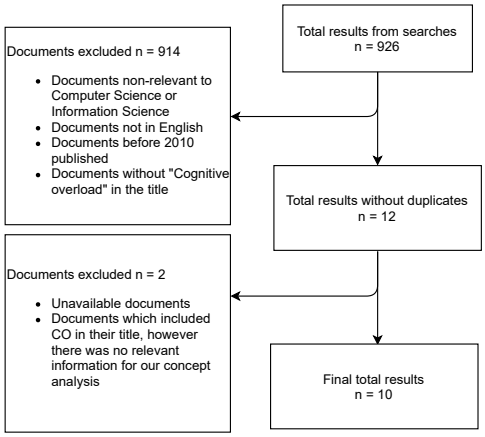
Finally, during the **further development phase**, the aim is to apply the newly gained knowledge and offer further questions and hypothesis to answer. Researchers should use the information collected in the previous phase to extract themes that will establish connections and define the concept. The findings during the offer other academics the opportunity to research the concept further and confirm the findings through experiments.

3.2. *Data sources*

We searched the terms 'information overload' and 'cognitive overload' in three databases: ACM Digital Library, SCOPUS, and LISA. The total number of returned results was 926 for CO and 6204 for IO. These results were limited to the



(a) Information overload literature



(b) Cognitive overload literature

Fig. 1: Survey flow

ones from (a) the last ten years from 2010 to September 2020, (b) in the English language, and (c) from the fields of computer science and/or information science. We refined our search to obtain a more manageable sample by limiting the results to (d) only the documents that had the terms in their titles. The refined search resulted in 213 documents for IO (Fig. 1a), and 12 items for CO (Fig. 1b). We performed further refinement during the core analysis phase, where documents that were unavailable or in a foreign language were removed (fig. 1). In addition to 'cognitive overload', we identified two other surrogates for IO: 'information anxiety' and 'infobesity'. We choose these two surrogates as these were the most recurrent in the papers we had sampled previously in our dataset. We performed a concept analysis for both. For the first term, 'information anxiety', we found seven papers. Across

our analysis, we found that 'information anxiety' has overlapping themes with IO; however, the two terms do not necessarily share the same themes. Therefore, we decided to consider 'information anxiety' as a related term rather than a surrogate. Meanwhile, for 'infobesity', we found only one paper, which shared the same themes as IO (Maidullah and Sharma, 2019).

3.3. *Procedure*

Each paper was read in its entirety to extract various elements necessary for the concept analysis.

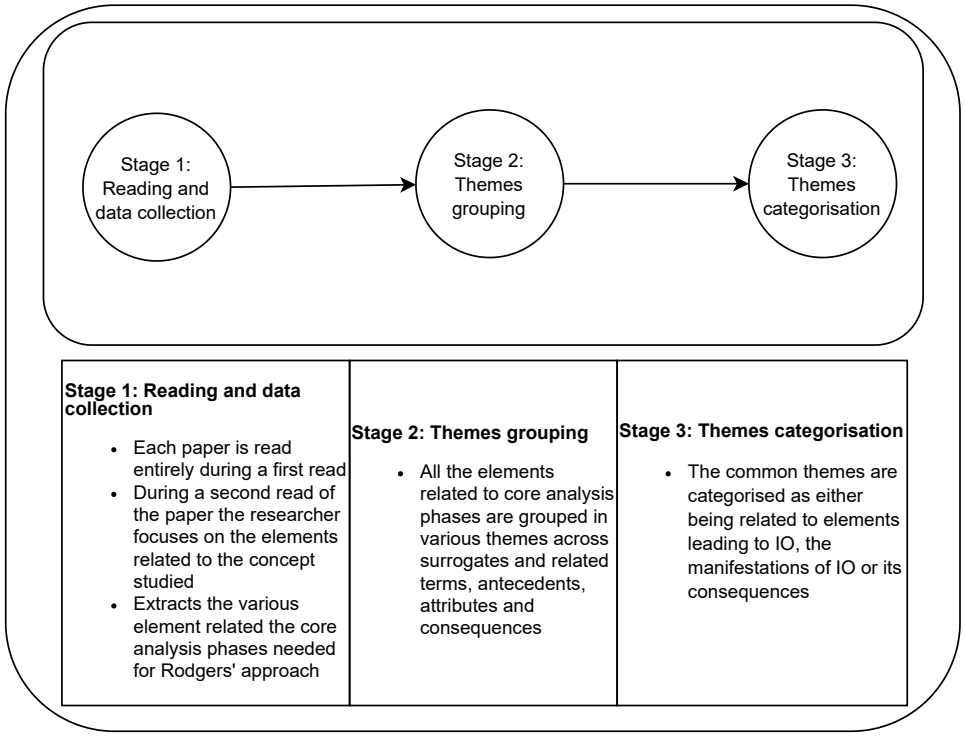


Fig. 2: Concept analysis process

For each document, we first read it in its entirety and highlighted the paragraphs related to IO. During the second read, we went back to the various paragraphs related to IO. We extracted words that are used interchangeably with IO (surrogates), the words which have overlapping themes with IO (related terms), the causes leading to IO (antecedents), the way IO manifests itself (attributes) and the consequences. We next grouped each of the elements identified in the core analysis phase under the themes we defined (Fig. 3). These are presented in section 4.

4. Findings

In this section, we explain how we used the papers in our dataset to establish the key attributes that helped us define 'information overload'.

Through the core analysis phase, we found the same themes across the IO and CO papers. Within the corpus of IO and CO, various papers used both terms interchangeably. Therefore, we combined our findings under the concept of IO, identified recurrent patterns, and established main themes across the literature. The themes fit into three categories (Fig. 3): triggers, manifestations, and consequences. The triggers consisted of the elements leading to IO. The manifestations of IO can be separated into two classes: emotional (i.e. mental health) and cognitive (i.e. individual limitations). The consequences can be subsequently separated into two types: internal consequences and external consequences. In this section, we will introduce each component and establish its connections.

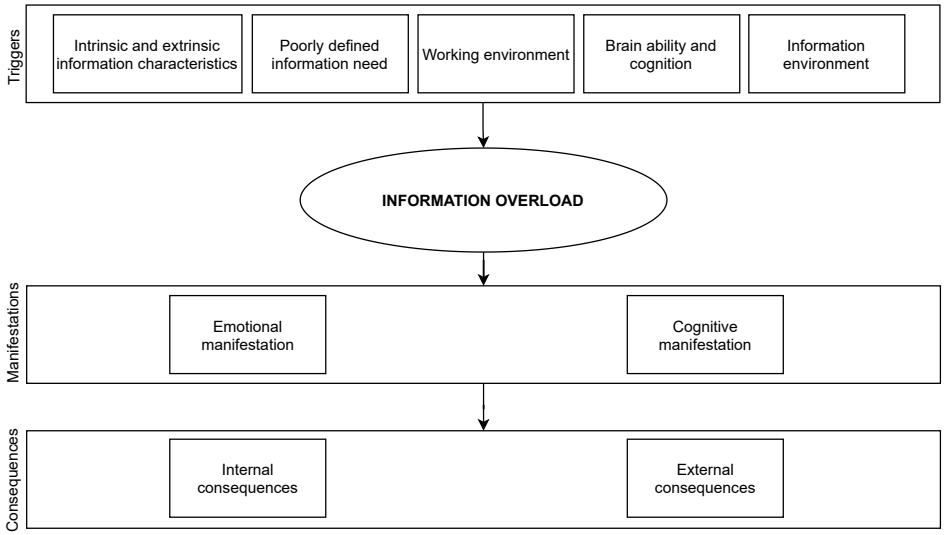


Fig. 3: The various themes identified for IO

Triggers

We identified five main themes, grouped under 'triggers', which capture the elements leading to IO. The triggers include: an individual's cognitive state, a poorly defined information need, the characteristics of the information, the environment of the information, or the environment in which an individual interacts with information.

Intrinsic and extrinsic information characteristics. Both the intrinsic and extrinsic characteristics of information have an impact on whether individuals will be subject to IO. The intrinsic characteristics of information encapsulate elements of infor-

mation such as quality and diversity. One example from our dataset has shown that vagueness of terms (Keselman et al., 2010), the relevance of information, and diversity of information (Lincoln, 2011) are all potential triggers for IO. Luo et al. (2013) have shown consistent information was perceived to induce lower IO when compared to inconsistent information. There has also been work highlighting the importance of structured information in mitigating IO (Tzagarakis et al., 2014): Poghosyan (2019) demonstrated that journalists having access to well-structured flows of information allows them to write more concise explanatory articles and therefore limits the risk of IO. Similarly, in the work by Dutta (2011), well-structured flows of information enable business executives to contextualise information better and improve their decision-making which would otherwise be negatively impacted by IO. Meanwhile, the extrinsic characteristics of information relate to the quantity of information, speed of information, and amount of sources offering information, whether relevant or not (Jackson and Farzaneh, 2012, Katz et al., 2011). In one study, people who handled information at a high speed felt it contributed to IO because it negatively impacted their ability to absorb the information and reflect on it (Benselin and Ragsdell, 2016). Kao and Peng (2015) found that users of a multi-source book review system could find useful reviews faster than users of general-purpose search engines like Google, as they were exposed to a less diverse range of information.

Poorly defined information need. A poorly defined information need can trigger IO as users with a poor understanding of the search domain are exposed to a large corpus of information and have to filter it (Swar et al., 2017). In our dataset, we read a paper by Simperl et al. (2010) which explained that to reduce IO for enterprise workers, it is essential to understand their information needs and show them the most prominent search results related to their task.

Working environment. The working environment is about the real-world environment in which the users find information while performing a search task. Previews work has shown unsolicited information (Saxena and Lamest, 2018), task difficulty and intensity, whether the user is exposed to information without breaks (Abdullah and Mustapar, 2019, Jackson and Farzaneh, 2012, Ouardi et al., 2016, Paul and Nazareth, 2010, Whelan and Teigland, 2013) are all elements leading to IO. Hargittai et al. (2012), in their review, found that time sensitivity, defined as the time given to review available information, is a condition leading to IO.

Brain ability and cognition. Another trigger is brain ability and cognition (BAAC). Across the literature, surrogates and related terms for IO appeared to be related to cognition, such as cognitive overload and working memory saturation (Bera, 2012, Shrivastav and Hiltz, 2013, Virkus et al., 2017). Virkus et al. (2017) found that information science (IS) students were more likely to perceive IO than informatics students, although the IS students believed their knowledge of databases and information resources allowed them to better cope with it. Meanwhile, informatics students used various information and communication technologies and were less likely to perceive IO. This follows the findings regarding the extrinsic factors

of information (Jackson and Farzaneh, 2012, Katz et al., 2011). Finally, differences between individuals such as gender and age can determine if a person will be subject to IO (Shrivastav and Hiltz, 2013). Schmitt et al. (2018) showed a higher age, differences in social motives and a lack of information retrieval strategies all lead to IO.

Information environment. The information environment consists of how and where the information is presented. It is about the design of the interface presenting the information (Chen et al., 2011, Fu et al., 2020, Rutkowski and Saunders, 2010, Strother et al., 2012*a*) and its ability to filter the information as per the user's information need (D'Asaro et al., 2013, Whelan and Teigland, 2011, Yang and Albers, 2013). Wu et al. (2015), through an eye-tracking study, were able to show that interface complexity increased cognitive workload and user efficiency in the context of LED manufacturing systems. Another paper demonstrated how unfiltered information increased the complexity of managing information in online reputation management systems (Yang and Albers, 2013). Ensuring the information environment can filter relevant from irrelevant information reduces the impact of the increasing amount of information (D'Asaro et al., 2013, Whelan and Teigland, 2011, Yang and Albers, 2013). When the user is exposed to items that are not relevant, this exacerbates the poor understanding of information (Jacobfeuerborn and Muraszkiewicz, 2013) and limits the learning as well. Finally, there has also been work looking at whether systems showing familiar information to all members of a collaborative environment favoured decision-making fuelled by cognitive biases such as confirmation bias (Minas and Crosby, 2016).

Manifestations

The triggers mentioned above lead to IO, which presents itself through emotional and cognitive manifestations.

Emotional manifestation. The emotional manifestation of IO is about the mental health of the user (Ndumu, 2020). From our dataset, we found work demonstrating that IO prompts feelings such as fatigue, information anxiety (Ndumu, 2020), and stress (Matthes et al., 2020, Melinat et al., 2014). Individuals under IO have less time for contemplative activities which results in strong emotions such as sadness and depression (Lauri and Virkus, 2018, Mustapar et al., 2016, Ndumu, 2020, Virkus et al., 2017). Phillips-Wren and Adya (2020) have shown in their review of decision-making under stress that individuals with a high perception of IO were subject to stress. When combined with uncertainty, this leads to lower confidence, fear, and poorer quality decision-making.

Cognitive manifestation. The cognitive manifestation of IO relates to individual limitations. These appear as symptoms of individuals experiencing IO at the cognitive level. Individuals subject to IO are unable to develop their knowledge. (Jacobfeuerborn and Muraszkiewicz, 2013). They suffer from cognitive dissonance (Strother et al., 2012*b*), burnout, and lack of concentration (Mustapar et al., 2016,

Tran et al., 2019) They may start avoiding some sources or discontinuing their search for information (Wild et al., 2012). Zhang (2018), in their survey of students in online collaborative environments, found that when suffering from IO, they pay less attention and when facing new information, they ignored it. Individuals suffering from IO were prone to lower their standards, tolerate errors and poor quality of work, and approach tasks with a negative attitude (Hu and Chen, 2011).

Consequences

Both the emotional and cognitive manifestations lead to consequences, whether on the individual or the individual's surrounding environment. We divided these into internal and external consequences.

Internal consequences. The internal consequences of IO relate to the impact it has on the individuals themselves. Individuals subject to IO suffered from low creativity (Rötzel and Fehrenbacher, 2019, Sabeeh and Ismail, 2013, Strother et al., n.d., Virkus et al., 2017), attention issues (Koltay, 2017), poor learning and skill acquisition (Green, 2011), poor well-being (Jackson and Farzaneh, 2012, Tan and Kuo, 2019), less trust (Furner and Zinko, 2017), and had more demands on their working memory (Lauri and Virkus, 2018, Rötzel and Fehrenbacher, 2019). Swar et al. (2017) have found that due to the ill-being generated by IO during online healthcare information search, individuals discontinued their search and therefore were not able to learn anymore. Sabeeh and Ismail (2013), in their review of the effects of IO in an enterprise, have found that venture capitalists with too much information found it difficult to learn, and it led to lower creativity in their problem-solving.

External consequences. These encapsulate all the consequences on the surrounding environment in which the users find themselves. We found numerous external consequences such as poor decision-making (Strother et al., n.d.), poor productivity, drop-out/withdrawal from the task (Swar et al., 2017, Wild et al., 2012), and poor collaboration (Koroleva et al., 2010, Rötzel and Fehrenbacher, 2019). In addition, consequences of IO can vary from financial loss (Rötzel and Fehrenbacher, 2019) to mistakes costing lives: In 2010, 23 Afghan civilians were left dead following a US drone attack, investigations have shown that the drone operator was flooded with information and ended ignoring some which were critical (Management, 2011).

Definition

Through the findings presented above, this concept analysis resulted in the following definition of IO: Information overload is a negative psychological state in which individuals feel that they are receiving too much information, which hinders their ability to carry out their tasks. IO manifests itself through emotional and cognitive challenges and is most likely to happen through intrinsic and extrinsic information characteristics, poorly defined information needs, their working environment, brain

ability and cognition, or the information environment. The emotional and cognitive manifestations result in both internal and external consequences. The internal consequences limit the ability of individuals to learn and inhibit their creativity. The external consequences impact the working environment of individuals. It translates into poor decision-making, which can result in both financial and human cost.

5. Discussion and conclusion

In their overview, Bawden and Robinson (2021) have shown that IO is an important problem which has propagated to organisations, societies and individuals, and that there is no consensus on the definition. They group the causes of IO in four groups: quantity of information, diversity, complexity and novelty of information, pushed information, and factors related to individuals. In our paper, we offer a model which encapsulates these various causes. The first two groups (quantity of information and intrinsic characteristics of information) fit within our intrinsic and extrinsic information characteristics trigger; pushed information falls within our working environment trigger, and the factors related to the individuals go within the brain ability and cognition trigger. We have studied the various causes and consequences of IO in computer science and information science research from the period spanning 2010 to September 2020 with the aim of providing a comprehensive definition for IO.

This work provides a reproducible approach to describing, clarifying and defining IO in computer science and information science. It also showed that from 2010 to September 2020, the papers discussing CO are actually tackling IO. We categorised the various elements of the concept of IO and provided researchers with a clearly operationalised model to better study, observe, and work toward reducing the human problems associated with IO.

In our introduction, we presented the most popular definition of IO, which is to consider it a phenomenon that happens when there is a large amount of relevant and potentially useful information; however, this information becomes an obstacle rather than a benefit to an individual's learning. We also highlighted the definition of CO from cognitive psychology, in which CO is understood to happen when the amount of information held by the individual is too high and will minimise individuals' cognitive performance. However, we believe these definitions are both limited in the context of the modern age. This work has clearly highlighted that IO is more than just about the quantity of information and its relevance.

In conclusion, we have offered a model which can be used to study IO in an information-based society better. Our model establishes triggers that can be used to lead individuals to experience IO and detect the moment IO happens through the consequences of IO. These triggers and consequences could also be used to develop models which detect when IO is happening. While we were able to determine the various triggers leading to IO, we do not know whether they are equally influential or not. In other words, we do not know whether there are triggers that are more

prone to lead to IO than others, or the amount of time each trigger takes to lead to IO. We have also shown that while there are components that can be controlled to generate IO, others such as the working environment, cannot be controlled.

Future work can look at whether there are different IO levels and the individual differences that can determine who is more likely to be subject to IO. They can use the triggers we defined to generate IO and investigate the users who are most subject to IO by looking at the consequences. This would allow us to study individual differences better. Also, we offer an overview of IO manifestations which can be used to understand them better and potentially allow to develop training that might inhibit these emotional and cognitive manifestations.

We believe our work provides a stepping-stone for further theoretical and practical work. It presents key factors in IO, which would allow new ways to measure it and identify elements that can be modified at the system level to limit the risks of falling into a state of IO. Better information systems can reduce IO's cognitive and emotional impact, which would allow cognitive development to be more creative and, therefore, allow users to be more confident and make better decisions.

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