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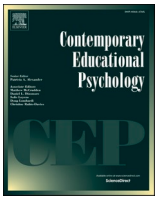

Effects of media multitasking on the processing and comprehension of multiple documents: Does main idea summarization make a difference?

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ABSTRACT

Media multitasking refers to simultaneous engagement in two activities, or the act of switching between multiple activities, of which at least one is a media activity. Based on this definition, we had 134 Norwegian undergraduates read four partly conflicting documents on sun exposure and health on a computer in order to write a report on the issue, with half of the participants (randomly assigned) receiving and reading short, authentic social media messages on a smartphone while reading the documents, and the other half reading the documents without being sent any such messages. Further, we manipulated what participants did after reading each document paragraph, with half of the participants (randomly assigned) briefly summarizing the main idea of each paragraph in writing, and the other half just rereading each paragraph. Participants' integrative processing (i.e., cross-text elaboration strategies) were assessed with a task-specific self-report measure immediately after reading all four documents, and their comprehension of the documents was assessed by analyzing their written reports in terms of their ability to elaborate and integrate information within and across the perspectives discussed in the documents. Results indicated that social media multitasking on a smartphone disturbed both the integrative processing and the integrated understanding of the documents, with main idea summarization mitigating or counteracting these negative effects of multitasking. However, when controlling for working memory, reading comprehension skills, and prior knowledge, integrative processing was not found to mediate the effect of multitasking on integrated understanding of the documents. Limitations of the present study and directions for future research are discussed.

1. Introduction

Multitasking involves simultaneous performance of two or more independent tasks or rapid, non-sequential switching between those tasks (Carrier, Rosen, Cheever, & Lim, 2015; Junco & Cotton, 2012; Koch, Poljac, Müller, & Kiesel, 2018; Salvucci & Taatgen, 2011). Media multitasking simply refers to multitasking contexts in which at least one of the tasks involves the use of media (Aagaard, 2015; Luo, Yeung, & Li, 2020; Wood & Zivcakova, 2015). Multitasking contexts also differ according to whether the performed tasks are compatible or non-compatible, with compatible tasks being functionally similar in the sense that they have common goals and non-compatible tasks being functionally different in the sense that they serve separate goals (Lin & Bigenho, 2015; Strayer, Castro, Turrill, & Cooper, 2022).

Although the extant work on multitasking represents diverse areas ranging from basic cognitive research on dual-task and task-switching performance to research on multitasking in relation to ageing and driving, multitasking in educationally relevant contexts has become a main area of research in the last decades (Różańska & Gruszka, 2020). Accordingly, in the current study, we focused on the effects of media multitasking when students performed the educationally relevant task of reading a set of digital documents on a laptop computer in order to construct an integrated understanding of a controversial socio-scientific issue (McCrudden, Bråten, & Salmerón, 2023). While performing this cognitively resource-demanding primary task, students were intermittently required to switch to a non-compatible and thereby potentially distracting task involving social media use on a smartphone. In this way, we created an experimental scenario intended to mimic real-life study contexts in which readers are constantly being derailed by other media use or even by the mere thought of using other media while studying (Hollis & Was, 2016; Jamet, Gonthier, Cojean, Colliot, & Erhel, 2020; Wood & Zivcakova, 2015). By focusing on the primary task of reading to comprehend multiple documents, this study is the first that brings together the two burgeoning areas of multitasking in an educational

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context and multiple document comprehension. Arguably, this extension of multitasking research to multiple document comprehension may enrich research on both multitasking and reading comprehension, broadening the research agenda in both areas and providing new insights into the nature of authentic reading in a permanently online, permanently connected society (Vorderer, Hefner, Reinecke, & Klimmt, 2018).

In the following sections, we provide a brief theoretical background analysis focusing on the constructs of multitasking and multiple document comprehension, as well as a brief review of prior work on the effects of media multitasking on students' learning and performance. Because we also investigated whether main idea summarization during document reading might moderate the potentially negative effects of social media multitasking on the processing and comprehension of multiple documents, we also include a brief discussion of the summarization approach before we return to the unique features of the present study and the specific research questions and hypotheses that guided our empirical work.

1.1. Why is multitasking unfavorable?

There are several possible reasons why students may switch from a primary, academic task to a non-compatible media task. According to the exploitation-exploration model of media multitasking proposed by Wiradhany, Baumgartner, and de Bruin (2021), students may start to explore alternative tasks when primary task engagement (i.e., exploitation) decreases, with this shift being driven by both internal and environmental cues. For example, students may switch to social media use during the reading of an academic informational text because they are curious, bored, or tired, or simply because of the multiple affordances represented by media technologies (e.g., entertainment, social connection; Wiradhany et al., 2021).

Among the theoretical frameworks that may help explain the cognitive cost of multitasking for primary task processing and performance are the classic cognitive bottleneck theory (Welford, 1967) and the memory for multiple goals model (Altmann & Trafton, 2002), as well as the broader cognitive load theory (Sweller, Ayres, & Kalyuga, 2011) and cognitive theory of multimedia learning (Mayer, 2014). In particular, the theory of threaded cognition (Salvucci & Taatgen, 2008,2011) is a contemporary framework well suited to explain the challenges involved in switching back and forth between tasks (i.e., intermittent multitasking). Basically, this theory assumes that the processing of multiple, active tasks that draw on overlapping cognitive, perceptual, or motor resources has to be done in a serial manner. That is, in such multitask contexts, the processing thread of one task is given exclusive access to these resources while the processing threads of other active tasks and goals must wait until the processing of that task is completed (Salvucci & Taatgen, 2011). Further, whereas this rule of exclusivity means that the processing thread of a task will grab and hold on to its resources in a "greedy" manner, the theory of threaded cognition also maintains that a processing thread is "polite" in the sense that it readily hands over these resources to queuing tasks when its job is done (Salvucci & Taatgen, 2008). This means, for example, that students who decide to halt their reading of an academic text and turn to a non-compatible media task drawing on overlapping resources (e.g., reading social media messages) will have access to the resources needed to process the secondary task (politeness) but not be able to think about the primary task simultaneously (exclusiveness). As a consequence, they will likely experience a break in coherence that makes it more challenging to construct an integrated understanding of the text content when resuming the primary task.

Recently, Strayer et al. (2022) questioned the politeness of current task threads in releasing processing resources that are no longer needed, as posited by the theory of threaded cognition. According to these authors, the processing thread of a particular task is not only greedy in requiring goal-relevant processing resources as soon as possible, but also quite "sticky" in "gumming up the works until the information is slowly purged from working memory" (Strayer et al., 2022, p. 277). In essence, this means that when switching back to the primary task, interference from a secondary non-compatible task using overlapping resources may persist well after the secondary task has been completed.[1]

1.2. The task of processing and comprehending multiple documents

Leading theorists largely agree that text comprehension involves building a coherent mental representation of text content, that is, a representation that integrates content across different parts of the text as well as across text content and readers' prior knowledge relevant to that content (e.g., Graesser, 2007; Kintsch, 1998; van den Broek, 2010). Although such integration sometimes may proceed automatically, strategic processing, that is, effortful, intentional, and purposeful processing, is quite often needed (Afflerbach, Pearson, & Paris, 2008; Graesser, 2007; Kendeou & O'Brien, 2018). When readers are tasked to comprehend not one but multiple documents on the same topic, issue, or phenomenon, content integration is required not only within but also across documents (Perfetti, Rouet, & Britt, 1999). Thus, in order to make sense of a topic, issue, or phenomenon discussed in different documents, readers need to connect, combine, or organize information across these documents (Barzilai, Zohar, & Mor-Hagani, 2018). Although this is a quite common reading task in the document-rich and information-saturated learning context of the 21st century (McCrudden et al., 2023; Strømsø & Bråten, 2022), it has also been shown to be a formidable challenge for students regardless of educational level (Bråten, Braasch, & Salmerón, 2020).

Automatic resonance processes may play a role in content integration when the amount of semantic overlap among documents is high (Beker, Jolles, Lorch, & van den Broek, 2016; Beker, van den Broek, & Jolles, 2019; Kurby, Britt, & Magliano, 2005). Typically, however, strategic processing directed toward the goal of integrating information across documents seems to be involved in multiple document comprehension (Afflerbach & Cho, 2009; Cho & Afflerbach, 2017; List & Alexander, 2019). More specifically, Afflerbach and Cho's (2009; Cho & Afflerbach, 2017) taxonomy of constructively responsive reading comprehension strategies for reading multiple and digital texts includes the main categories of (a) identifying intertextual links and meaning making across texts, (b) monitoring the construction of intertextual relationships, and (c) evaluating the content of multiple texts. Likewise, the importance of intertextual strategies in the form of cross-textual linking and reasoning about cross-textual links, as well as additional strategies involving perspective-taking, organization, and evaluation, is highlighted within the integrated framework of multiple text use by List and Alexander (2019). Of note is that this emphasis on intertextual strategic processing has received extensive empirical support, with a range of studies linking cross-text elaboration strategies, in particular, to multiple document comprehension (e.g., Anmarkrud, Bråten, & Strømsø, 2014; Bråten, Anmarkrud, Brandmo, & Strømsø, 2014; Bråten & Strømsø, 2011; Cho, Woodward, Li, & Barlow, 2017; Follmer & Tise, 2022; Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Hagen, Braasch, & Bråten, 2014; List & Alexander, 2020; List, Du, Wang, & Lee. 2019; McCrudden, Huynh, Lyu, & Kulikowich, 2021; Sonia et al., 2022). Essentially, such strategies involve connecting, comparing, and contrasting content across multiple documents in order to construct an integrated understanding of the topic, issue, or phenomenon in question. While some of these studies have used verbal protocol analysis to assess students' intertextual strategy use (Anmarkrud et al., 2014; Cho et al., 2017; Goldman et al., 2012; List, Du, et al., 2019, Study 2; McCrudden

[1] Although Strayer et al.'s (2022) argument was based on experimental multitasking work in the area of driving, their notion of persistent negative effects of intermittent multitasking on processing and performance also seems highly relevant to other areas of multitasking research.

et al., 2021; Sonia et al., 2022), others have used a task-specific self-report inventory administered right after the multiple document task (Bråten et al., 2014; Bråten & Strømsø, 2011; Follmer & Tise, 2022; Hagen et al., 2014; List, Du, et al., 2019, Study 1).

Given the complexity of multiple document comprehension and the strategic processing involved in such reading tasks, it seems likely that the processing and comprehension of multiple documents are particularly vulnerable to switching back and forth between such tasks and other, non-compatible tasks drawing on overlapping resources. In particular, it seems reasonable to assume that media multitasking while reading to understand multiple documents may disturb both the integrative processing and the integrated products of multiple document comprehension.

1.3. Prior research

Although prior research has not examined effects of multitasking on multiple document comprehension, both correlational and experimental studies have established links between students' multitasking and their learning and performance, including their performance on reading tasks. Regarding the correlational studies, many have assessed students' habitual media multitasking by using a decontextualized self-report measure, such as the Media Multitasking Index (Ophir, Nass, & Wagner, 2009) or some adaptation of this measure (e.g., Baumgartner, Lemmens, Weeda, & Huizinga, 2017). In sum, the correlational studies have indicated that there is a negative relationship between students' reports of media multitasking habits, both in and out of school, and their academic performance (e.g., Alghamdi, Karpinski, Lepp, & Barkley, 2020; Bellur, Nowak, & Hull, 2015; Gaudreau, Miranda, & Gareau, 2014; Junco & Cotton, 2012; Kane et al., 2021; Kokoc, 2021; Lau, 2017; Luo et al., 2020; Martín-Perpiñá, Poch, & Cerrato, 2019).

Correlational studies thus provide some evidence to suggest that off-task media multitasking (e.g., social media use) in educational contexts (during homework and in class) may lower students' academic performance. However, these studies typically are limited by the fact that they have not gathered students' reports of media multitasking in a specific learning task context and related those self-reports to their performance on that task. As an example of a contextualized correlational self-report study, Jamet et al. (2020) asked undergraduates who did not know in advance that they were participating in research on multitasking to self-report the number and duration of off-task media multitasking activities (e.g., messaging) they had engaged in right after a class session on a cognitive psychology topic. Then, students' learning of the content taught in the same session was assessed. It was found that there was a unique negative relation between students' task-specific self-reports of off-task multitasking activities and their learning outcomes after controlling for domain and topic interest, but not between their reports of multitasking and performance on a subsequent problem-solving transfer task.

Regarding the experimental studies, many studies have shown that students required to engage in media multitasking (e.g., off-task messaging) during simulated or actual lectures have learned less lecture content than students not engaged in such media multitasking (e.g., Conard & Marsh, 2014; Kuznekoff & Titsworth, 2013; Rosen, Lim, Carrier, & Cheever, 2011; Sana, Weston, & Cepeda, 2013; Waite, Lindberg, Ernst, Bowman, & Levine, 2018; Wood et al., 2011). As suggested by Rosen et al. (2018), the amount of media multitasking seems to play a role in such contexts. Accordingly, those authors found that students who were required to read and respond to at least 16 messages while viewing a 30-min videotaped lecture learned less lecture content than did students who read and responded to fewer than seven messages.

In a recent within-subjects experimental lab study, Ekuni, Macacare, and Pompeia (2022) had Brazilian undergraduate students read a 700-word informational text on a laptop computer in three different conditions. In the first condition, the students read the text while receiving and reading three brief messages on their cell phone (at approx. 90-s intervals), before they were asked to reread seven paragraphs of the informational text. In the second condition, the students engaged in similar multitasking while reading the text but instead of rereading, they subsequently engaged in retrieval practice by trying to answer questions based on seven text paragraphs. In the third condition, the students read the informational text without any multitasking, followed by the same type of retrieval practice as in the second condition. Of note is that the students read a different 700-word informational text in each condition (i.e., counterbalanced). In brief, the results suggested that answering questions about the content of text paragraphs after reading could mitigate negative effects of multitasking because there was no difference in recall of text information between the second and the third condition and both these conditions outperformed the first one. Although Ekuni et al.'s (2022) work is highly relevant to the current study and presented some interesting results, it is also somewhat limited because the design was not a balanced 2×2 design and because the dependent measure targeted memory for factual information rather than text comprehension.

Finally, in a recent *meta*-analysis including 20 experimental studies investigating the effect of multitasking on text comprehension, Clinton-Lisell (2021) found an overall negative effect of $g = -0.28$, with this negative effect increasing to $g = -0.52$ when the reading time was restricted. It should be noted, however, that many of these studies included vague descriptions of the experimental texts and that there were serious issues with respect to the validity and/or reliability of the outcome measures that were used in the vast majority of the studies (e.g., only four studies included any information about the reliability of the text comprehension measures). Moreover, the vast majority of the studies used multiple-choice questions to measure text comprehension and none focused on the comprehension of multiple texts or documents. The effects of media multitasking on the integrative processing and integrated understanding of multiple documents are thus an area wide open for further research.

1.4. Main idea summarization

In discussing how writing about the reading material may influence text comprehension, McNamara and Allen (2018) noted that summarization of the text content may strengthen readers' mental representation of the content and thus improve their recall as well as their conceptual understanding of the text. Presumably, this is because summarization requires that readers identify the main ideas in paragraphs and distinguish between more and less relevant text information (Graham & Nusrat, 2023; McNamara & Allen, 2018). Regarding single text comprehension, Graham and Hiebert (2011), in a meta-analytic study, found that across 19 studies the overall effect size for written summarization was 0.54.

Regarding multiple text comprehension, Barzilai et al. (2018) reviewed studies implementing instructional practices to promote integration across multiple texts, finding that nearly half of these studies included summarization or annotation of singe texts as an instructional approach. Further, most of these studies were found to be effective in improving intertextual integration. According to Barzilai et al. (2018), summarizing single texts within a text set "may help students identify and select important and relevant ideas from the texts" as well as "develop better organized, more durable representations that can be drawn on more readily when reading subsequent texts" (p. 994).

In an early study using this approach, Britt and Sommer (2004) found that students who read two 600-word history texts that described the same event from different perspectives and wrote a summary of the first text before reading the second one, integrated content from the two texts better than did students who read the second text immediately after the first one. As a recent example, Follmer and Tise (2022) presented students with two 32–34-sentence conflicting texts on the issue of gun control and assessed their cross-text elaboration strategies and their integrated understanding of the texts' content. These authors found that

students who summarized more and less important information in each text as well as information that was consistent and inconsistent between the two texts, gained a more integrated understanding of the issue, as mediated by their use of cross-text elaboration strategies, than did students in a rereading condition who simply reread both texts.

In the current study, we built on prior work showing positive effects of summarization on text comprehension and examined the extent to which summarizing the main ideas of text paragraphs might mitigate any negative effects of media multitasking on integrative processing and integrated understanding of multiple documents. Compared to a general endorsement of main idea summarization in the literature, the effectiveness of just rereading or restudying the material for learning and performance has been questioned (e.g., Ekuni et al., 2022; Karpicke & Roediger, 2008; Rowland, 2014; Wallace, Elliot, & Rogge, 2022). Because the latter also seems to be a very popular strategy among students (Hartwig & Dunlosky, 2012; Wallace et al., 2022), we compared main idea summarization with rereading as potential moderators in the current study.

1.5. Controlling individual differences

This study concerned effects of media multitasking and main idea summarization rather than individual differences. Therefore, we considered it important to control for potential effects of working memory capacity, reading comprehension, and prior knowledge. These individual difference variables were chosen as covariates because prior research has indicated that they may be related to both integrative processing and integrated understanding of multiple documents (e.g., Braasch, Bråten, Strømsø, & Anmarkrud, 2014; Bråten et al., 2014; Florit, Cain, & Mason, 2019; Mahlow et al., 2020). Thus, working memory likely plays a role in inference generation and content integration to construct a coherent mental representation based on the documents' content as well as readers' prior knowledge (Follmer & Sperling, 2020; Tarchi, Ruffini, & Pecini, 2021). Reading comprehension is relevant because readers' situational (i.e., inferential) understanding of each single text may be considered the cognitive building blocks of cross-text elaboration and understanding (McNamara & Magliano, 2009). Finally, prior knowledge of the issue discussed across documents is likely to impact multiple document processing and comprehension because it facilitates bridging inferences that create interconnection and coherence both within and across documents (Bråten, Braasch, & Salmerón, 2020; McCrudden et al., 2023).

1.6. The present study

This study represents a unique extension of prior research on both media multitasking and multiple document comprehension by investigating to what extent integrative processing and integrated understanding of multiple informational documents differ when students, while reading these documents on a laptop computer, intermittently engage in non-compatible social media multitasking on a smartphone. Building on theoretical perspectives (Cho & Afflerbach, 2017; List & Alexander, 2019; Salvucci & Taatgen, 2008, 2011; Strayer et al., 2022) as well as empirical findings (Clinton-Lisell, 2021; Jamet et al., 2020; Ekuni et al., 2022) discussed in the previous sections, we hypothesized that participants who read four partly conflicting documents on the controversial issue of sun exposure and health while media multitasking would report less integrative processing and display poorer integrated understanding of the content of the documents than would participants who read the same four documents without any multitasking.

Further, based on prior research (Barzilai et al., 2018; Britt & Sommer, 2004; Ekuni et al., 2022; Follmer & Tise, 2022; Rowland, 2014; Wallace et al., 2022), we hypothesized that participants required to summarize in writing the main idea of each paragraph of the four documents would report more integrative processing and display better integrated understanding than would participants who just reread these paragraphs.

Regarding both integrative processing and integrated understanding, we also hypothesized that the effects of media multitasking would be moderated by written main idea summarization, with summarization assumed to reduce or eliminate any negative effects of media multitasking on integrative processing and integrated understanding of the documents.

Finally, we entertained the possibility that participants' integrative processing, as self-reported on a validated task-specific strategy inventory (Bråten & Strømsø, 2011), would mediate the presumed effect of media multitasking on integrated understanding of document content, as evidenced by post-reading written comprehension assessment. When engaged in intermittent media multitasking, participants' integrative processing of the documents is likely disturbed through interference from the secondary task (Salvucci & Taatgen, 2011; Strayer et al., 2022). Consistent with conceptualizations and prior research on the role of integrative processing in multiple document comprehension (Bråten et al., 2014; Cho & Afflerbach, 2017; List & Alexander, 2019; List, Du, et al., 2019), it also seems likely that participants who engage in less integrative processing display less integrated understanding of the documents. Consequentially, a mediated effect of media multitasking on integrated understanding via integrative processing could be expected.

By including working memory capacity, reading comprehension skills, and prior knowledge about the topic as covariates, we wanted to ensure that any effects of our experimental manipulations occurred independently of these individual difference variables.

2. Method

2.1. Participants

Participants were 134 students at the University of Oslo who were enrolled in programs in education (31.4 %), special education (23.1 %), arts and humanities (22.4 %), social sciences (21.6 %), and informatics and mathematics (1.5 %). Sixty-three participants were first-year bachelor students, 36 were second-year bachelor students, and 31 were third-year bachelor students, with only four participants being enrolled in master level programs at the time of data collection. Their overall mean age was 24.03 years ($SD = 6.40$), and 76.9 % identified as female, 18.7 % as male, and 3.0 % as other (2 participants did not report on gender identification). Most participants (67.2 %) had Norwegian as their sole language background, while 17.9 % had another language background, and 14.9 % had a mixed language background (i.e., Norwegian and another language). However, 95 % of the participants were graduated from a Norwegian high school and all their current university level programs were taught in Norwegian. Participation in the study was voluntary and each participant received a gift card worth approximately USD 20 after the data collection. The collection and handling of the data were in accordance with the Norwegian Personal Data Registers Act and were approved by the Norwegian Social Science Data Services.

2.2. Materials

2.2.1. Documents and experimental manipulations

Participants read four separate documents on the controversial issue of sun exposure and health, with two of the documents presenting conflicting perspectives on the issue of sun exposure and physical health and the two other presenting conflicting perspectives on the issue of sun exposure and mental health. The different perspectives were based on authentic materials and represented genuine controversies concerning this socio-scientific issue (e.g., Moan, Baturaite, Juzeniene, & Porojnicu, 2012). The four documents were adapted, longer versions of documents used in prior research on multiple document comprehension (Delgado, Stang Lund, Salmerón, & Bråten, 2020; Stang Lund, Bråten, Brandmo, Brante, & Strømsø, 2019) They ranged in length from 600 to 612 words ($M = 606.50$, $SD = 5.00$), and based on Björnsson (1968) formula, the

readability scores ranged from 40 to 49 ($M = 45.25$, $SD = 4.11$), indicating that their difficulty level was comparable to that of informational texts published by the Norwegian government (Vinje, 1982). At the beginning of each document, source information was presented in the form of the author's name, credentials, and affiliation, in addition to the publication venue and date of publication.

Regarding the two documents on sun exposure and physical health, one document presented and elaborated the perspective that sun exposure is harmful because it may cause skin cancer, whereas the other document presented and elaborated the perspective that sun exposure is healthy because it may protect against all forms of cancer through the production of vitamin D. For example, the perspective that sun exposure may lead to skin cancer was elaborated in terms of the underlying mechanism (UV-radiation can damage DNA) and the types of skin cancer that may occur (basal-cell carcinoma and melanoma), and the perspective that sun exposure may protect against all forms of cancer was elaborated in terms of the underlying mechanism (cells use vitamin D to stay normal) and types of cancer and other illnesses vitamin D may protect against (e.g., colon cancer, osteoporosis). Regarding the two documents on sun exposure and mental health, one document presented and elaborated the perspective that lack of sun exposure may lead to depression, whereas the other document presented and elaborated the perspective that lack of sunlight may lead to sleeplessness (but not depression). For example, the perspective that lack of sun exposure may cause depression was elaborated in terms of the underlying mechanisms (decrease in serotonin and increase in melatonin) and the type of depression that may occur (seasonal affective disorder), and the perspective that lack of sunlight may lead to sleeplessness was elaborated in terms of underlying mechanisms (changes in the secretion of melatonin and disturbance of the diurnal rhythm) and evidence against the theory that lack of sunlight causes depression. English versions of all four documents are included in the online supplemental materials.

Multitasking was manipulated between participants, with half of the participants (randomly assigned) reading the documents on a laptop computer while intermittently opening and checking brief social media messages on a smartphone. The laptop was a HP EliteBook 840 G7 with a 14″ screen at a resolution of 1920 × 1080 pixels, and the smartphone was a Samsung Galaxy A02s with a 6.5″ screen at a resolution of 720 × 1600 pixels. The messages were eight authentic social media messages taken from Facebook, Instagram, and Tik Tok, including a commentated Facebook video of an old man dancing, an Instagram post with a picture and comments on the 10-year anniversary of a Justin Bieber concert that wreaked havoc in the city center of Oslo, and a Tik Tok video of fluffy puppies falling down a step with music in the background. Each of the eight messages took about 10 s to open and check, with this estimate based on a careful piloting of the materials. The four documents were divided into four paragraphs each, with the number of words in the 16 paragraphs ranging from 109 to 208 ($M = 147.56$, $SD = 25.42$). Participants in the multitasking condition received a message signaled by phone vibration while reading every second of the 16 paragraphs, with half of the participants receiving the eight messages in odd numbered paragraphs (first, third, fifth, etc.) and half of them receiving the eight messages in even numbered paragraphs (second, fourth, sixth, etc.). The order of the eight messages was random for each participant, and at which point in a paragraph each participant received a message was also random. The experimenter sent a participant a message in Snap Chat a few seconds after the participant had started on this paragraph, which could be observed by the experimenter due to the set-up in the lab (see the *Procedure* section). However, because of the varying file sizes of the different messages, somewhat varying internet speed, and varying reading speed among participants, the messages were received at random points in the assigned paragraphs. The participants who were randomly assigned to the non-multitasking condition just read the same four documents divided into four paragraphs each without receiving any messages while reading.

In addition to the multitasking manipulation, we manipulated main idea summarization between participants, such that half of the participants (randomly assigned) after each paragraph were asked to summarize the main idea of that paragraph in a designated textbox with no word limit. The other half of the participants were after each paragraph asked to reread that paragraph and tick a checkbox when they had done so.

For all participants, the issue of sun exposure and physical health and the issue of sun exposure and mental health were presented in counterbalanced order, as were the two documents discussing each issue. The four paragraphs within each document were always presented in a fixed order, however.

2.2.2. Outcome measures

In the next sections, we describe the outcome measures of integrative processing and integrated understanding of the documents. With respect to integrated understanding, our system for scoring the written products and the way we established interrater reliability are also described.

Integrative processing. Participants' integrative processing was assessed with an adapted version of the 10-item cross-text elaboration subscale of the Multiple-Text Strategy Inventory (MTSI) developed by Bråten and Strømsø (2011). This is a task-specific strategy inventory (Bråten, Magliano, & Salmerón, 2020) designed to measure the extent to which readers try to compare, contrast, and connect content across multiple documents. The inventory was completed immediately after participants had finished reading the four documents on sun exposure and health, and all the items referred back to the reading of these documents (sample items: I tried to understand the relationship between sun exposure and health by comparing the content of the different documents; I considered whether the documents represented contradictory views on sun exposure and health; I considered whether different explanations of the relationship between sun exposure and health can be reconciled). Participants rated the extent to which they had performed each described activity while reading the four documents on a 10-point scale ranging from *not at all* (1) to *to a very large extent* (10). We divided the scores by the number of items such that the scores on this measure ranged from 1 to 10. The internal consistency reliability (Cronbach's alpha) for participants' scores was 0.92.

Of note is that a range of previous studies have shown construct validity for scores on this task-specific strategy measure, such as by exploratory and confirmatory factor analyses (Bråten & Strømsø, 2011), correspondence with integrative processing traced in study materials (Hagen et al., 2014) or verbal protocols (List, Du, et al., 2019, Study 2), and positive associations with multiple document comprehension (Bråten et al., 2014; Bråten & Strømsø, 2011; Follmer & Tise, 2022; Hagen et al., 2014; List, Du, et al., 2019, Study 1).

Integrated understanding. We measured participants' integrated understanding of the documents' content by means of post-reading written reports explaining the relationship between sun exposure, health, and illness. For each of the four perspectives presented and elaborated in the documents, two regarding sun exposure and physical health and two regarding sun exposure and mental health (see description of the documents above), participants were awarded 0–2 points. A score of 0 was given if a perspective (e.g., that sun exposure is harmful because it may lead to skin cancer) was not represented in the report, a score of 1 was given if a perspective was represented but not elaborated, and a score of 2 was given if a perspective was both represented and elaborated (e.g., by referring to the mechanism by which sun exposure may lead to skin cancer).

In addition, participants were awarded 0–2 points for integration of the two perspectives concerning sun exposure and physical health and 0–2 points for integration of the two perspectives concerning sun exposure and mental health. A score of 0 was given if there was no attempt to compare, contrast, or connect two of these perspectives, a score of 1 was given if two of these perspectives were compared, contrasted, or connected (e.g., by acknowledging that sun exposure may have both negative and positive effects on physical health) but such

integration was not explicitly elaborated, and a score of 2 was given if attempts to compare, contrast, or connect two of these perspectives were explicitly elaborated (e.g., by trying to reconcile the two perspectives by weighing the risk of skin cancer against the need to obtain sufficient vitamin D).

Finally, participants were awarded 0–2 points for integration of perspectives across the two issues discussed in the documents (i.e., the issue of sun exposure and physical health and the issue of sun exposure and mental health). A score of 0 was given if there was no attempt to integrate perspectives across the two issues, a score of 1 was given if perspectives across the two issues were compared, contrasted, or connected (e.g., by acknowledging that both physical and mental health may be influenced by UV-radiation from the sun) but such integration across issues was not elaborated, and a score of 2 was given if integration of perspectives across the two issues was explicitly elaborated (e.g., by explaining how lack of sunlight during winter might involve a risk of physical illness due to less vitamin D and a risk of mental illness due to less serotonin). Please see Appendix A for further description and exemplification of the entire scoring system.

In summary, the total scores on our written comprehension assessment could possibly range from 0 to 14, with 0–8 points awarded for representing and elaborating the four perspectives discussed in the documents and 0–6 additional points awarded for integrating information across the perspectives and issues discussed in the document set. Of note is that no additional points were given for integration unless the respective perspectives were also represented in the written reports. High scores on this measure can thus be said to reflect an elaborated and integrated understanding of the documents' content. Only the total scores on this measure were used in subsequent statistical analyses.

Blind to the experimental conditions, the first and second authors scored all the written reports. After having scored 14 reports collaboratively to develop the scoring system, they scored a random selection of 30 reports independently. The independent scoring resulted in a somewhat lower than desirable, yet acceptable (Landis & Koch, 1977) Cohen's Kappa of 0.65, and a very high correlation between the two raters' total scores (Pearson's $r = 0.93$). All disagreements were solved in a thorough discussion in which the requirements for receiving 2 points on the perspective regarding sun exposure and skin cancer and for receiving 1 and 2 points, respectively, on the perspective regarding sun exposure and vitamin D were further specified (these points were responsible for most of the disagreements). The two raters then scored the remaining reports separately.

2.2.3. Covariates

In the next sections, we describe the measures of working memory, reading comprehension, and prior knowledge that were included as potential covariates in this study.

Measure of working memory. Working memory was measured with a Norwegian adaptation of Swanson and Trahan (1992) Working Memory Span Task, which is based on the technique originally developed by Daneman and Carpenter (1980). The Norwegian adaptation has been used and validated in much prior work with postsecondary students (e.g., Bråten, Latini, & Haverkamp, 2022; Delgado et al., 2020; Haverkamp & Bråten, 2024). The materials consisted of 42 unrelated declarative sentences, five to 12 words in length, which were organized into 12 sets of sentences. The number of sentences in each set increased from two to five, and the sentences in each set were read aloud to participants with an interval of two seconds between each sentence. Participants were asked to comprehend the sentences so that they could answer a question about the content of one of the sentences as soon as the final sentence in the set was read. Then, on the same response form, they should write down the final word of each sentence in the set. The working memory task was scored by counting the total number of final words recalled across all 12 sets (possible maximum score = 42) but points were awarded for correctly recalled final words only if the comprehension question for the set was answered correctly. The internal consistency reliability (Cronbach's α) for participants' scores on the measure was 0.87.

Measure of reading comprehension. We assessed reading comprehension by means of a Norwegian adaptation of a cloze test developed by Jensen and Elbro (2022), which required readers to draw global, situation level (Kintsch, 1998) inferences in order to fill in each of the gaps. This measure consisted of 34 2-4-sentence passages with one gap in each passage and four alternative words provided for each gap. Correct refilling of the gaps could only be achieved by drawing inferences regarding the global situation described in the passage (i.e., situation model construction; Kintsch, 1998). As an example, an English translation of one passage read:

> She had to be ready in two hours so she was in a bit of a rush. The bag was already in the car and the ticket, keys, and wallet were in her pocket. Her husband ran after her with her [*passport*, packed lunch, shopping list, USB key]. It was lucky, otherwise she would not have got very far.
> (Jensen & Elbro, 2022, p. 1233)

The Danish version of this measure was validated by Jensen and Elbro (2022), who demonstrated that the scores of adult readers were highly correlated with their scores on a standardized reading comprehension test as well as with their scores on other reading-relevant measures (vocabulary, sentence comprehension, topic identification). Recently, Salmerón, Altamura, Blanco, Montagud, and Vargas (2022) also provided some preliminary validation data for a Spanish adaptation of this measure.

Participants read the passages and refilled as many gaps as possible during a period of 10 min. Scoring was done by counting the number of correctly refilled gaps (possible maximum score = 34). The internal consistency reliability for participants' scores on the measure (Cronbach's α) was 0.84.

Measure of prior knowledge. We assessed knowledge about the broader issue of sun exposure and health by means of a 17-item multiple-choice measure that also has been used and validated in prior research (e.g., Stang Lund, Bråten, Brante, & Strømsø, 2017; Stang Lund et al., 2019). The items of this measure referred to information and concepts that were relevant to the content of the four documents, covering sun exposure in relation to both physical and mental health (e.g., skin cancer, production of vitamin D, depression, and sleeplessness). Participants' scores were the number of correct responses out of 17. The internal consistency reliability for participants' prior knowledge scores (Cronbach's α) was 0.66. Some sample items for the prior knowledge measure are included in Appendix B.

2.3. Procedure

All data were collected individually in one 90-min session in a university lab by the first and third authors. Participants in all four experimental groups (i.e., multitasking/main idea summarization [$n = 34$], multitasking/rereading [$n = 32$], non-multitasking/main idea summarization [$n = 33$], non-multitasking/rereading [$n = 34$]) were first administered the working memory and reading comprehension measures on paper. Afterwards, they accessed a web-based questionnaire through a link on the screen of the laptop computer and completed a demographic survey and the prior knowledge measure. In the web-based questionnaire, the four documents were introduced in this way for all participants:

You are now going to read four texts about sun exposure, health, and illness that altogether consist of 2500 words. Afterwards, you are going to write a brief report based on these texts in which you explain the relationship between sun exposure, health, and illness. Each text consists of four paragraphs; please read all paragraphs in the order they appear on the next pages. It is important that you do what you are asked to do after each paragraph. You cannot look back to the texts when writing your report.

In addition, participants in the multitasking/main idea summarization and multitasking/rereading groups were told:

While reading you will receive some messages on this phone. The phone is going to vibrate when you receive a message. You have to open and read each of these messages as soon as you get it. When you have read the message, you have to go back to the home screen.

After each of the 16 paragraphs (four per document), participants in the multitasking/main idea summarization and non-multitasking/main idea summarization groups were instructed in writing to briefly summarize the main idea of the preceding paragraph in their own words, whereas participants in the multitasking/rereading and non-multitasking/rereading groups were instructed in writing to read the paragraph they just read once more. A textbox was available below the instruction for main idea summarization and a checkbox was available beside the instruction for ticking off the rereading. Participants who summarized main ideas had access to the paragraphs while summarizing them.

Of note is that the set-up in the lab was such that participants had their back to the experimenter while working with the documents, with the experimenter sitting in the other end of the room following participants' reading of the documents paragraph by paragraph on a large screen duplicating the screen of the laptop computer on participants' desk (see Fig. 1). From this position, the experimenter sent a new message to the phone located on participants' desk during the reading of every other paragraph and also ensured that the message was opened and read by the participants in the multitasking condition (there was no phone on the desk in the non-multitasking condition). The experimenter could see the part of the desk on which participants' phone was located and actually observe that they opened and read the messages once receiving them (the experimenter could also hear the sound of videos being played). Because the messages were sent in Snap Chat, the experimenter could also ensure that participants were online and checked the messages via this application. If participants only glanced briefly at the phone or did not watch the entire video, they were orally reminded "please remember to read/view the entire message." On the large screen, the experimenter could also check that participants in the main idea condition actually wrote something in the textbox and that participants in the rereading condition ticked the checkbox before proceeding to the next paragraph. Of note is that summarization could also not be skipped because the designated textboxes were listed as obligatory elements in the program used for the web-based questionnaire. That is, if participants did not write in a textbox, it would be not be possible to continue to the next page and they were automatically sent back to that textbook (which was left open and highlighted in red).

Immediately after having finished reading the documents, all participants completed the 10-item measure of integrative processing in the web-based questionnaire. Finally, they read the following writing prompt:

There are different points of view on the relationship between the amount of sun exposure, health, and illness. You are now going to write a report in which you explain important similarities and differences between these points of view. Base your report on the texts you just read and try to express yourself as clearly and completely as possible, preferably in your own words.

Participants completed their report in a textbox with no word limit that was located right below this writing prompt and submitted it to a server when finished.

3. Results

3.1. Preliminary analyses

Table 1 includes descriptive information and zero-order correlations for all measured variables for the entire sample. All scores were

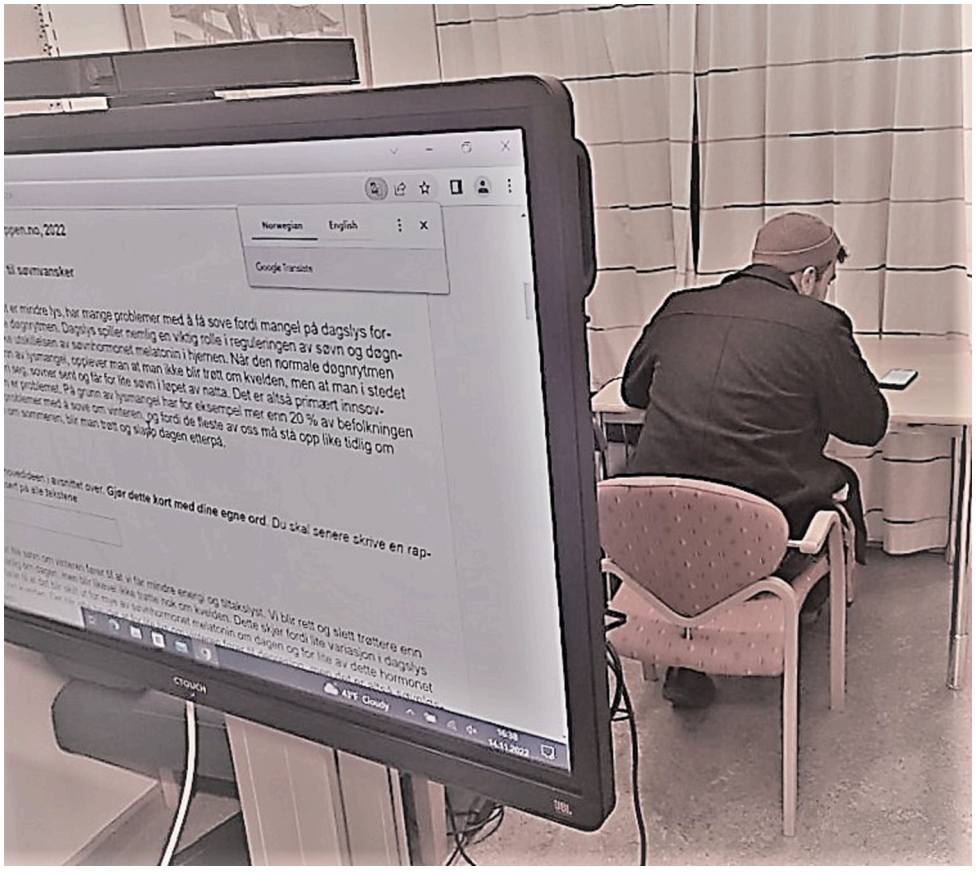

Fig. 1. The set-up in the lab.

Table 1
Descriptive information and zero-order correlations for the entire sample.

Variable	1	2	3	4	5
1. Working memory	–	–			
2. Reading comprehension skills	0.399***	–			
3. Prior knowledge	0.236**	0.359***	–		
4. Integrative processing	0.135	0.220**	0.198*	–	
5. Integrated understanding	0.247**	0.420***	0.392***	0.267**	–
M	20.75	25.01	14.29	7.89	7.04
SD	8.18	4.89	2.32	1.59	3.22
Skewness	0.08	−0.95	−1.18	−0.67	−0.08

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

approximately normally distributed and suitable for parametric statistical analyses. The covariates of reading comprehension ($r = 0.220$, $p = .005$) and prior knowledge ($r = 0.198$, $p = .022$) but not working memory ($r = 0.135$, $p = .123$) were statistically significantly correlated with integrative processing, and all these covariates were statistically significantly correlated with integrated understanding (working memory: $r = 0.247$, $p = .004$; reading comprehension: $r = 0.420$, $p < .001$; prior knowledge: $r = 0.392$, $p < .001$. Further, the positive correlation between integrative processing and integrated understanding ($r = 0.267$, $p = .002$) indicated that the more participants compared, contrasted, and connected content across the documents when reading, the more able they were to construct an integrated understanding of the broader issue of sun exposure and health.

Table 2 shows descriptive information about the three covariates (i.e., working memory, reading comprehension, and prior knowledge) for each of the four experimental groups (i.e., multitasking/main idea summarization, multitasking/rereading, non-multitasking/main idea summarization, and non-multitasking/rereading). One-way analyses of variance (ANOVAs) with the four experimental groups as the independent variable and the three covariates as the dependent variables showed no statistically significant differences between the groups for any covariate, with $F(3, 129) = 0.27$, $p = .848$, $\eta^2 = 0.006$, for working memory; $F(3, 130) = 0.55$, $p = .648$, $\eta^2 = 0.013$, for reading comprehension; and $F(3, 130) = 2.11$, $p = .102$, $\eta^2 = 0.047$, for prior knowledge.

3.2. Effects on integrative processing

Descriptive information about integrative processing by experimental group is included in Table 2. We tested our hypotheses regarding main and interactive effects of multitasking and main idea summarization on integrative processing by performing a 2×2 between-subjects analysis of covariance (ANCOVA) with multitasking (i.e., multitasking or non-multitasking) and main idea summarization (i.e., main idea summarization or rereading) as the independent variables, scores on the cross-text elaboration inventory as the dependent variable, and reading comprehension and prior knowledge as covariates (working memory was not included as a covariate in this analysis because it did not correlate with the dependent variable; Field, 2018). Results of the evaluation of the assumptions for performing the ANCOVA were satisfactory.

This analysis resulted in a statistically significant main effect of multitasking on integrative processing (multitasking: $M = 7.60$, $SE = 0.19$; non-multitasking: $M = 8.17$, $SE = 0.19$; $F(1, 127) = 4.55$, $p = .035$, $\eta_p^2 = 0.035$). However, neither the main effect of main idea summarization (main idea summarization: $M = 7.94$, $SE = 0.19$; rereading: $M = 7.84$, $SE = 0.19$; $F(1, 127) = 0.13$, $p = .716$, $\eta_p^2 = 0.001$), nor the interactive effect of multitasking with main idea summarization, $F(1, 127) = 1.63$, $p = .204$, $\eta_p^2 = 0.013$, were statistically significant. Although the interaction was not statistically significant, the descriptive information included in Table 2 strongly suggested that the statistically significant negative effect of multitasking on integrative processing primarily was due to lower scores in the multitasking/rereading condition. Identifying the sole condition responsible for the negative effect of multitasking on integrative processing might be important not only for future work in this new area of research, but potentially also for instructional practice (i.e., by suggesting that the highly popular approach of rereading might be particularly vulnerable to multitasking in a multiple document reading context). We therefore conducted exploratory follow-up analysis of the simple effects of multitasking within each level of main idea summarization, finding that there, indeed, was a statistically significant effect of multitasking for those who were rereading each paragraph, $F(1, 127) = 5.87$, $p = .017$, $\eta_p^2 = 0.044$, but not for those who were summarizing the main idea of each paragraph, $F(1, 127) = 0.34$, $p = .56$, $\eta_p^2 = 0.003$. Thus, participants who engaged in multitasking during reading ($M = 7.38$, $SE = 0.27$) reported statistically significantly less integrative processing than did participants who did not multitask ($M = 8.30$, $SE = 0.27$) when they reread each paragraph. When participants summarized the main idea of each paragraph, however, there was no statistically significant difference in integrative processing between those who did or did not multitask (multitasking: $M = 7.82$, $SE = 0.26$; non-multitasking: $M = 8.05$, $SE = 0.28$). Tests of the simple effects of main idea summarization within each level of multitasking showed no statistically significant effect whether participants were not multitasking, $F(1, 127) = 0.41$, $p = .525$, $\eta_p^2 = 0.003$, or multitasking, $F(1, 127) = 1.39$, $p = .240$, $\eta_p^2 = 0.011$. None of the covariates statistically significantly adjusted integrative processing, with $F(1, 127) = 3.72$, $p = .056$, $\eta_p^2 = 0.028$, for reading comprehension, and $F(1, 127) = 2.35$, $p = .128$, $\eta_p^2 = 0.018$, for prior knowledge. Fig. 2 displays the results of the ANCOVA using integrative processing as the outcome variable.

3.3. Effects on integrated understanding

Descriptive information about integrated understanding by

Table 2
Descriptive statistics for the measured variables by experimental group.

	Multitasking		Non-multitasking	
	Main idea	Rereading	Main idea	Rereading
Working memory	20.14 (8.14)	20.69 (8.31)	21.82 (8.24)	20.38 (8.31)
Reading comprehension	24.97 (4.27)	25.09 (4.83)	25.76 (5.57)	24.24 (4.91)
Prior knowledge	14.53 (2.05)	14.52 (1.93)	13.44 (2.97)	14.68 (2.06)
Integrative processing	7.84 (1.42)	7.40 (1.85)	8.02 (1.55)	8.29 (1.48)
Integrated understanding	6.94 (2.81)	6.34 (3.43)	6.64 (3.16)	8.18 (3.31)

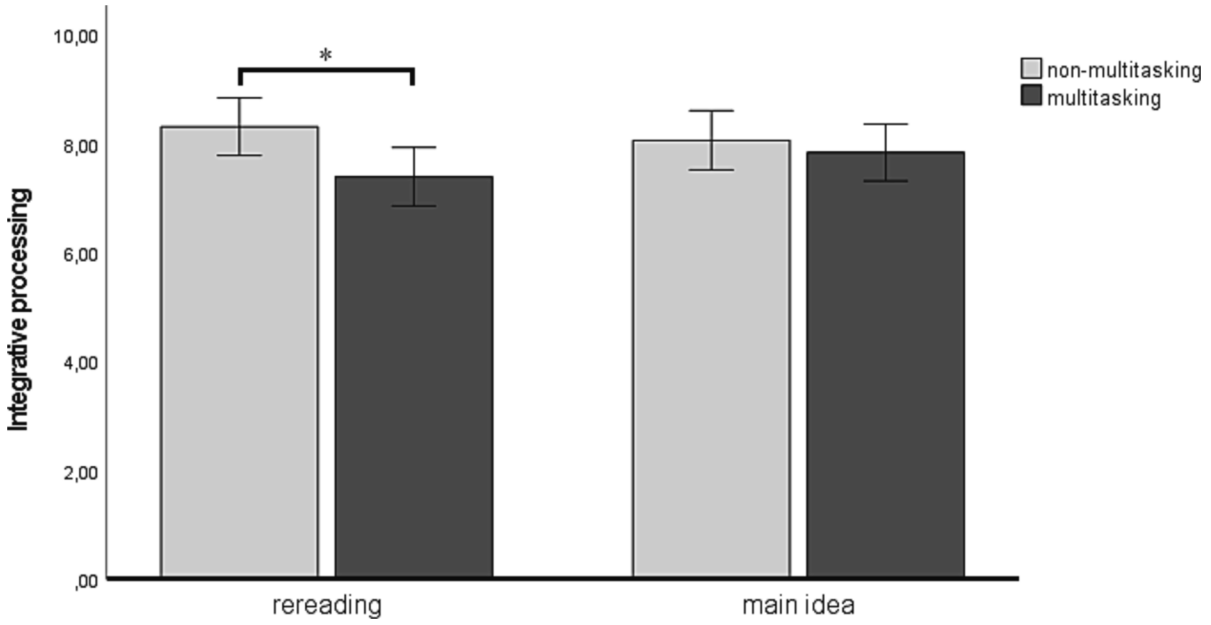

Fig. 2. Integrative processing for rereading and main idea summarization by multitasking condition (multitasking vs. non-multitasking). Error bars represent standard errors.

experimental group is also included in Table 2. We tested our hypotheses regarding main and interactive effects of multitasking and main idea summarization on integrated understanding by means of a 2×2 between-subjects ANCOVA including multitasking (i.e., multitasking or non-multitasking) and main idea summarization (i.e., main idea summarization or rereading) as the independent variables, scores on the written reports about sun exposure and health as the dependent variable, and working memory, reading comprehension, and prior knowledge as covariates. Results of evaluation of the assumptions for performing this ANCOVA were also satisfactory.

The results showed that there was a statistically significant main effect of multitasking (multitasking: $M = 6.57$, $SE = 0.34$; non-multitasking: $M = 7.52$, $SE = 0.34$; $F(1, 125) = 3.81$, $p = .05$, $\eta_p^2 = 0.030$) but no main effect of main idea summarization (main idea summarization: $M = 6.85$, $SE = 0.34$; rereading: $M = 7.24$, $SE = 0.34$; $F(1, 125) = 0.65$, $p = .423$, $\eta_p^2 = 0.005$) on integrated understanding. Further, the main effect of multitasking was modified by a statistically significant interaction between multitasking and main idea

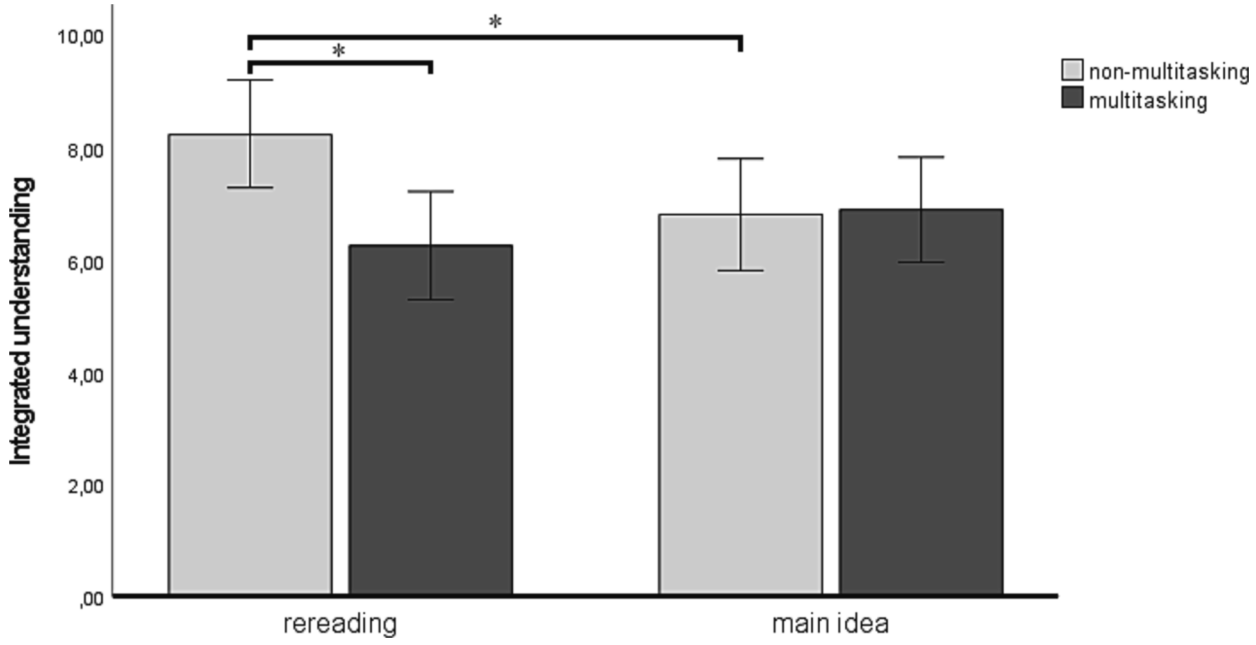

Fig. 3. Integrated understanding for rereading and main idea summarization by multitasking condition (multitasking vs. non-multitasking). Error bars represent standard errors.

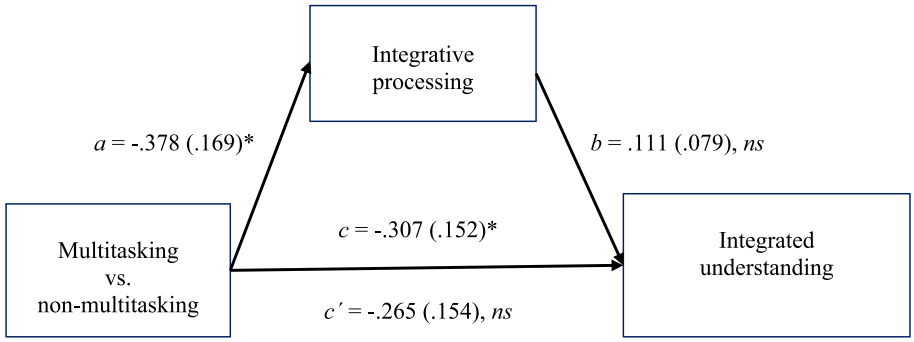

Fig. 4. Mediation model for the effect of multitasking on integrated understanding with integrative processing as a mediator (standardized coefficients).

summarization on integrated understanding, $F(1, 125) = 4.43$, $p = .037$, $\eta_p^2 = 0.034$.

Tests of the simple effects of multitasking within each level of main idea summarization showed that there was a statistically significant effect of multitasking for those who were rereading each paragraph, $F(1, 125) = 8.45$, $p = .004$, $\eta_p^2 = 0.063$, but not for those who were summarizing the main idea of each paragraph, $F(1, 125) = 0.02$, $p = .90$, $\eta_p^2 = 0.000$. Thus, participants who engaged in multitasking during reading ($M = 6.25$, $SE = 0.49$) obtained statistically significantly lower scores on integrated understanding than did participants who did not multitask ($M = 8.23$, $SE = 0.48$) when they reread each paragraph. However, when participants instead summarized the main idea of each paragraph, there was no statistically significant difference in integrated understanding between those who did or did not multitask during reading (multitasking: $M = 6.89$, $SE = 0.47$; non-multitasking: $M = 6.81$, $SE = 0.50$).

Further, tests of the simple effects of main idea summarization within each level of multitasking showed that there was a statistically significant effect when participants were not multitasking, $F(1, 125) = 4.07$, $p = .046$, $\eta_p^2 = 0.032$, but not when they were multitasking, $F(1, 125) = 0.89$, $p = .348$, $\eta_p^2 = 0.007$. Thus, when participants were not multitasking, they actually obtained statistically significantly higher scores on integrated understanding when they were rereading each paragraph ($M = 8.23$, $SE = 0.48$) than when they were summarizing the main idea of each paragraph ($M = 6.81$, $SE = 0.50$). However, when participants were multitasking, there was no statistically significant difference between those who reread ($M = 6.25$, $SE = 0.49$) and those who summarized the main idea of each paragraph ($M = 6.89$, $SE = 0.47$).

The covariates of reading comprehension, $F(1, 125) = 14.66$, $p < .001$, $\eta_p^2 = 0.105$, and prior knowledge, $F(1, 125) = 8.83$, $p = .004$, $\eta_p^2 = 0.066$, but not the covariate of working memory, $F(1, 125) = 0.66$, $p = .418$, $\eta_p 2 = 0.005$, uniquely adjusted participants' integrated understanding scores. Fig. 3 displays the results of the ANCOVA using integrated understanding as the outcome measure.

3.4. Mediation analysis

We used the bootstrapping approach available in the PROCESS Procedure for SPSS Version 4.0 (Hayes, 2022) to explore the possibility that integrative processing would mediate a negative effect of multitasking on integrated understanding. The mediation effect was tested with a bootstrap mediation approach with 5000 samples. We coded multitasking 1 and non-multitasking 0 and included the covariates of working memory, reading comprehension, and prior knowledge in this analysis. The results are displayed in Fig. 4.

The model explained a statistically significant portion of the variance, $R^2 = 0.29$, $F(5, 126) = 10.18$, $p < .0001$. There was a statistically significant negative effect of multitasking on integrative processing, $b = -0.378$, $SE = 0.169$, $p = .027$. However, the positive effect of integrative processing on integrated understanding was not statistically significant, $b = 0.111$, $SE = 0.079$, $p = .164$, and the mediated effect of multitasking on integrated understanding via integrative processing was also not statistically significant, with an estimate of -0.042 ($CI_{95\%}$: -0.115—0.013). A mediated effect of -0.042 means that as a consequence of multitasking, compared to not multitasking, there was only a 0.14 point decrease in integrated understanding due to the mediated effect (i.e., 4.2 % of a standard deviation). The covariates of reading comprehension ($b = 0.284$, $SE = 0.087$, $p = .001$) and prior knowledge ($b = 0.274$, $SE = 0.082$, $p = .001$) but not working memory ($b = 0.05$, $SE = 0.082$, $p = .544$) uniquely adjusted integrated understanding when integrative processing also was taken into account. Thus, although integrative processing and integrated understanding were positively correlated (see Table 1) and the total effect represented by the *c* coefficient was statistically significant ($b = -0.307$, $SE = 0.152$, $p = .045$) whereas the direct effect represented by the *ć* coefficient was statistically non-significant ($b = -0.265$, $SE = 0.154$, $p = .088$), mediation could not be demonstrated in this analysis, likely due to the multiple covariates that we included in the mediation analysis (see *Discussion* below).[2]

4. Discussion

Of course, students engaged in distracting tasks in educational contexts long before the advent of the Internet and social media platforms, for example, by talking with others in the reading room or by writing and sending notes to each other during lectures. However, permanent connection to the Internet and such platforms via mobile devices has vastly increased the pool and accessibility of potential distractors that can compromise students' ability to focus on school-relevant tasks, such as building an integrated understanding from a set of documents representing different perspectives on a topic, issue, or phenomenon. By providing new insights into the effects of media multitasking on

[2] We also conducted a moderated mediation analysis to examine whether the indirect effect of multitasking (i.e., multitasking vs. non-multitasking) on integrated understanding via integrative processing would vary with summarization condition (i.e., main idea summarization vs. rereading). Specifically, we analyzed our data using Model 8 for conditional processes in the PROCESS Procedure for SPSS Version 4.0 (Hayes, 2022). The results of this analysis showed that none of the conditional indirect effects of multitasking on integrated understanding were statistically significant, with −0.018, $SE = 0.028$, $CI_{95\%}$: −0.076—0.040, for the summarization condition; and −0.057, $SE = 0.053$, $CI_{95\%}$: −0.176—0.029, for the rereading condition. In this analysis, the index of moderated mediation also did not indicate a statistically significant difference between the indirect effects of the summarization and rereading conditions, with an index of 0.039, $SE = 0.054$, $CI_{95\%}$: −0.028—0.178.

students' processing and understanding of multiple documents, this study may give further impetus to a line of research that aims to better align the world of reading research with the world of real life reading (Bråten, Braasch, & Salmerón, 2020).

We first hypothesized that media multitasking would disturb both the integrative processing and the integrated understanding of the documents presenting different perspectives on sun exposure and health. Accordingly, our results indicated that switching between reading the documents and reading non-compatible social media messages affected students' processes and products of multiple document comprehension negatively. Presumably, students experienced breaks in coherence when their goal-relevant cognitive resources were exclusively devoted to the non-compatible social media task (Salvucci & Taatgen, 2011) as well as persistent interference from this task when resuming the multiple document task (Strayer et al., 2022). As a consequence, not only their effort to compare, contrast, and connect information across documents but also the coherence of the resulting mental representation of document content were disturbed.

Although we also hypothesized that main idea summarization would benefit both integrative processing and integrated understanding whether participants were multitasking or not, those who summarized the main idea of each paragraph did not generally outperform those who reread each paragraph on any of the outcome measures. This suggests that paragraph-by-paragraph main idea summarization may not be universally more effective than paragraph-by-paragraph rereading in a context of building integrated understanding from multiple documents. Of note is that prior research on the effects of main idea summarization in multiple document contexts (Barzilai et al., 2018; Britt & Sommer, 2004; Follmer & Tise, 2022) has focused on the summarization of single documents rather than paragraphs, which may be more beneficial when integration is the outcome of interest. Further, whether main idea summarization may positively affect integrative processing and integrated understanding in a multiple document task context may be related to the quality of readers' summaries, with even adult readers sometimes struggling to identify main ideas in informational text (Butterfuss, McCarthy, Orcutt, Kendeou, & McNamara, 2023; McNamara et al., 2024). More research is therefore needed on which textual units (e.g., single texts vs. paragraphs) should be targeted in interventions focusing on main idea summarization in order to improve multiple document comprehension. Such research could also examine how participants might vary in their interpretations of the main idea instructions themselves (Butterfuss et al., 2023).

More important than any main effect (or the lack of it) on readers' processing and understanding, however, may be the finding that main idea summarization moderated the effects of multitasking, with only participants who reread each paragraph performing poorer with respect to integrative processing and integrated understanding when they intermittently engaged in non-compatible social media multitasking during reading. For participants who instead summarized the main idea of each paragraph, no negative effects of social media multitasking on the outcome measures were found. Of note is that this pattern was consistent across both outcome measures, although the interaction was statistically significant only for integrated understanding. However, because the statistical significance of a 2×2 interaction refers to a difference in differences produced by the four means collectively and a statistically non-significant interaction therefore can be associated with statistically significant simple effects (Levin, 1985), we, given our hypothesis and the potential importance of identifying the sole condition responsible for the negative effect of multitasking on integrative processing, found it warranted to move beyond the omnibus *F*-test and explore whether a negative effect of multitasking might be restricted to participants who reread each paragraph. All told, our findings were consistent with the idea that main idea summarization may mitigate or counteract a negative effect of multitasking on both integrative processing and integrated understanding of multiple documents. Presumably, this is because main idea summarization provided a scaffold needed by those who multitasked, which means that it likely helped them to identify, select, retain, and organize relevant information that could be drawn on to facilitate integration when reading subsequent paragraphs and documents (Barzilai et al., 2018).

Unexpectedly, we also found that when participants were not multitasking, those who reread each paragraph actually obtained higher scores on the written comprehension assessment than did those who summarized the main idea of each paragraph. This interesting finding may suggest that the functional value of main idea summarization may vary across multitasking and non-multitasking conditions, as well as that rereading of each paragraph may be a viable approach when students read multiple informational documents without engaging in any non-compatible multitasking activities. Recently, McNamara et al. (2024) also compared rereading and summarization in a multiple document context without any multitasking, finding that individuals who reread entire documents outperformed individuals who summarized entire documents with respect to certain aspects of post-reading integrated essay writing. These authors suggested that rereading actually may support comprehension through the refinement of mental models and increased content integration during rereading. More research comparing the effects of rereading and summarization of paragraphs or single documents in diverse multiple document task contexts is obviously needed to further clarify this issue.

Finally, we could not ascertain the expected mediated effect of multitasking on integrated understanding via integrative processing. A likely reason for this lack of a statistically significant mediation despite the negative effects of multitasking on both processing and understanding and the positive bivariate relationship between processing and understanding, is the strong, appropriate control provided by the covariates in this study (Rohrer, Hünermund, Arslan, & Elson, 2022). In particular, the covariates of reading comprehension and prior knowledge, which correlated positively with integrative processing, were both more strongly related to integrated understanding than was integrative processing, making it likely that the variance that integrative processing shared with integrated understanding already was accounted for by these two covariates. Future research using more objective measures of integrative processing, such as eye movements or trace data, may be needed to explore this mediation issue further.

There are also other limitations of this study that need to be addressed in future research, such as the particular sample that we included, the materials that we developed, and the outcome measures that we used. These limitations may inspire further work on media multitasking in multiple document task contexts to probe the generalizability of our findings. Further, the ways in which we implemented the multitasking and main idea summarization conditions, in particular, may have influenced our findings. For example, multitasking with more emotionally laden content, for a longer period of time, or by using the same device for reading and multitasking, may have yielded other results. Likewise, summarizing larger parts of the documents or entire documents, as well as summarizing orally rather than in writing, might influence the beneficial effects of main idea summarization. In particular, summarizing the content of entire documents in combination with summarizing the content of the entire document set with a focus on similarities and differences between the documents (Follmer & Tise, 2021) may be an effective approach that needs to be further tested. Such remaining issues imply that this is, indeed, an area wide open for future

research.

Although the effects that we observed in this study were not stellar, it could be argued that even rather small negative effects of social media multitasking on multiple document processing and comprehension, when reiterated over many reading episodes and documents, could produce accumulated negative effects that would hamper students' learning and comprehension considerably. There is also a possibility that we, given the experimental set-up, may have underestimated the detrimental effects of multitasking on processing and comprehension. That is, by taking part in research on goal-directed reading of informational text in an individual session with the researcher present in the same room, participants may have devoted less attention to the non-compatible messages than they otherwise would have done. Data collected after task completion to learn about participants' experiences in the multitasking condition might have provided valuable information in this regard. In any case, more research varying the experimental set-up, preferably in one and the same study, is highly needed.

Further, although we selected the covariates among individual differences that have been associated with both processing and comprehension of multiple documents in previous studies, other individual differences also seem relevant in future research on the effects of multitasking in a multiple document context. These include students' engagement and situational interest, which have been shown to play a role when students' read multiple documents for understanding (Bråten, Brante, & Strømsø, 2018; List, Stephens, & Alexander, 2019), and which also might moderate the effects of multitasking on measures of processing and comprehension. Likewise, students' topic beliefs and epistemic beliefs may come into play and influence students' processing and comprehension of multiple documents (Bråten & Strømsø, 2020; Richter & Maier, 2018). Future research could therefore profitably include such individual difference variables.

Finally, more intervention research targeting media multitasking and its effects is definitely needed. There are several recommendations on how students may be helped to handle media technologies in ways that do not interfere with school-related tasks, with such recommendations ranging from technology breaks in class to teaching technology literacy (Bowman, Waite, & Levine, 2015). According to Parry and le Roux (2019), interventions in the area of media multitasking can be categorized into (a) awareness interventions to promote metacognitive awareness of media use, task switching, or task importance, (b) restriction interventions to restrict use of a device or particular activities, and (c) mindfulness interventions to increase attention to and control over one's current experiences. In a systematic review of 15 interventions falling into these three categories, Parry and le Roux found that there was very little evidence regarding the effectiveness of these approaches for changing multitasking behavior or increasing cognitive control. Hopefully, the present study may inspire much-needed further work on media multitasking, for example, by expanding on the main idea summarization approach that we implemented.

CRediT authorship contribution statement

Ymkje E. Haverkamp: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Ivar Bråten:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Natalia Latini:** Methodology, Investigation. **Helge I. Strømsø:** Methodology.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Appendix A

Coding system for integrated understanding.

Representation and elaboration of the perspective "sun exposure is harmful because it may lead to skin cancer."

Score	Definition	Example
0	Perspective not represented in report.	One should stay away from both solarium and sunlight during those hours when the sun is at its strongest (between 10.00 and 16.00)
1	Perspective represented but not elaborated.	The UV radiation of sunlight is harmful and may contribute to the development of skin cancer.
2	Perspective represented and elaborated.	This is because sunlight may increase the risk of skin cancer. There are two types of cancer: melanoma and basal cell cancer. If one is exposed to large amounts of UV radiation over a long period of time, it will increase the risk of developing cancer. This is because UV radiation attacks the DNA in our cells.

Representation and elaboration of the perspective "sun exposure is healthy because of vitamin-D production."

Score	Definition	Example
0	Perspective not represented in report.	This text argues that solarium has only positive effects on the body.
1	Perspective represented but not elaborated.	Those who think that the sun helps improve the health are focusing on the intake of vitamin D, and on how this vitamin may protect against cancer.
2	Perspective represented and elaborated.	According to research, vitamin D may reduce the risk of developing certain types of cancer, especially in the internal organs. Vitamin D mainly is obtained through sunbathing, but in the winter season this can be a challenge in the Nordic countries.

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(*continued*)

Representation and elaboration of the perspective "lack of sun exposure may have negative consequences because it may lead to depression"

Score	Definition	Example
0	Perspective not represented in report.	During the winter it may be more difficult to get enough sunlight, and this affects the mood of about 30 % of the population.
1	Perspective represented but not elaborated.	Lack of sunlight may also trigger the illness depression, or more specifically, winter depression.
2	Perspective represented and elaborated.	One of the texts described winter depression as very serious, and as a direct consequence of lack of sunlight. The explanation was that a lack of sunlight reduced the level of serotonin while also increasing the levels of melatonin. These two signal substances play an essential role in how you feel.

Representation and elaboration of the perspective "lack of sun exposure may have negative consequences because it may lead to sleeplessness"

Score	Definition	Example
0	Perspective not represented in report.	Some claim that it is not depression but a lack of activity that leads to feeling down.
1	Perspective represented but not elaborated.	This text explains that a lack of sunlight contributes to sleeplessness, which is the central issue.
2	Perspective represented and elaborated.	When there is little sunlight during the winter, the level of melatonin in the body will increase, and this may cause a change in the diurnal rhythm. It will be more difficult to fall asleep at night because the body secretes more melatonin during the day, such that the body's diurnal rhythm becomes unstable. This turns into a vicious circle.

Integration of the two perspectives concerning sun exposure and physical health

Score	Definition	Example
0	No attempt to integrate	Examples include representing or elaborating only one of the two perspectives or representing or elaborating both perspectives without any attempt to compare, contrast, or connect them.
1	Perspectives compared, contrasted, or connected	In one of the texts it said that one should be cautious about too much sunlight, especially about the use of solariums because this could be linked to an increased risk of skin cancer. … To the contrary, another text said that one needs to spend time in the sun, not just because of vitamin D, but also because of protection against cancer in internal organs, breast, prostate, and other places.
2	Perspectives compared, contrasted, or connected, plus explicitly elaborated.	Some studies have shown that sunlight is extremely important in counteracting skin cancer, other studies show the opposite. When our skin is exposed to sunlight, our body produces vitamin D, which makes the cells stronger and prevents them from abnormal development so we don't get cancer. The UV radiation of sunlight is still harmful and may contribute to the development of skin cancer. It therefore seems to be a golden mean when it comes to the correct amount of sunlight for the body.

Integration of the two perspectives concerning sun exposure and mental health

Score	Definition	Example
0	No attempt to integrate	Examples include representing or elaborating only one of the two perspectives or representing or elaborating both perspectives without any attempt to compare, contrast, or connect them.
1	Perspectives compared, contrasted, or connected	To the contrary some studies show that this phenomenon [winter depression] is not depression, but rather a disrupted diurnal rhythm. When we have trouble falling asleep during the night, we are also not rested during the day when we have to perform.
2	Perspectives compared, contrasted, or connected, plus explicitly elaborated.	There is also disagreement between the two texts focusing on our mental condition. One of the texts explains that a lack of sunlight may contribute to a winter depression. But the other text explains that a lack of sunlight contributes to sleeplessness, which is the central issue. The claim that a lack of sunlight contributes to winter depression is criticized in this text. However these two texts have more similarities than the two other texts because they deal with sleeplessness and depression, and both these texts agree that a lack of sunlight may result in sleeplessness.

Integration of perspectives across the two issues discussed in the documents (the issue of sun exposure and physical health, and the issue of sun exposure and mental health)

Score	Definition	Example
0	No attempt to integrate perspectives across the two issues	Examples include representing or elaborating only one of the two issues or representing or elaborating both issues without any attempt to compare, contrast, or connect them.
1	Perspectives compared, contrasted, or connected across the two issues	Although sunlight may be dangerous for our skin, it has a positive effect in preventing 'winter depression'.
2	Perspectives across the two issues compared, contrasted, or connected, plus explicitly elaborated	It's not necessary to risk getting skin cancer to obtain vitamin D, avoid winter depression or sleep problems. One can avoid all these problems by staying outdoors in the sunlight using sunscreen. … Use sunscreen, go for a walk outside!

Appendix B

Sample items for the prior knowledge measure.

Vitamin D is produced in the body only when …

☐ we exercise

☐ the body is exposed to microwave radiation

☐ the skin cells are irradiated by ultraviolet radiation

☐ we sleep

Sunburn in children and adolescents …

☐ protects against sun damage later in life

☐ is less dangerous than in adults

☐ increases the risk of serious disease later in life

☐ is unpleasant, but harmless

Depression is a form of …

☐ meningitis

☐ mental illness

☐ mental retardation

☐ hyperactivity

Diurnal rhythm is …

☐ a unit of time

☐ humans' internal clock

☐ the relationship between day and night

☐ the earth's rotation around its own axis

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cedpsych.2024.102271.

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