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Effects of task experience and layout on learning from text and pictures with or without unnecessary picture descriptions

Gertjan Rop[1] | Anne Schüler[2] | Peter P.J.L. Verkoeijen[1,3] | Katharina Scheiter[2,5] | Tamara van Gog[4,5]

[1] Department of Psychology, Education, and Child Studies, Erasmus University Rotterdam, The Netherlands

[2] Leibniz-Institut für Wissensmedien, Germany

[3] Learning and Innovation Center, Avans University of Applied Sciences, The Netherlands

[4] Department of Education, Utrecht University, The Netherlands

[5] University of Tübingen, Germany

Correspondence
Gertjan Rop, Erasmus School of Social and Behavioural Sciences, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands.
Email: rop@essb.eur.nl

Abstract

The presentation of extraneous (i.e., irrelevant or unnecessary) information may hamper learning with multimedia. The present study examined whether people can learn to ignore unnecessary information with increasing experience with the task and whether this depends on the layout of that information. In two experiments, participants learned about the process of mitosis from a multimedia slideshow, with each slide presenting a combination of expository text and a picture on one of the stages in the process. Slides either contained no unnecessary text (control condition) or unnecessary text (i.e., merely describing the picture) either integrated in the picture (integrated condition) or presented underneath the picture (separated condition). Knowledge about the studied mitosis phase was tested immediately after each slide using a cloze test. Across Experiments 1 and 2, we did not find a reliable negative effect of the unnecessary text on cloze test performance. As a result, the question of whether task experience would reduce or eliminate that negative effect could not be answered. The eye movement data did confirm, however, that participants attended less to the unnecessary information with increasing task experience, suggesting that students can adapt their study strategy and learn to ignore unnecessary information.

KEYWORDS

cognitive load, extraneous processing, eye tracking, multimedia learning, study strategies

1 | INTRODUCTION

According to well-known multimedia design principles, presenting extraneous (i.e., irrelevant or unnecessary) information in study material should be avoided, as it hinders learning (for reviews, see Kalyuga & Sweller, 2014; Mayer & Fiorella, 2014). A recent study suggested, however, that task experience (i.e., familiarity with the design of the material) may be a boundary condition for the negative effect of extraneous information on learning, at least when this information is *pictorial* and *irrelevant* for the learning task (i.e., Rop, Van Wermeskerken, De Nooijer, Verkoeijen, & Van Gog, 2018). In this study on word learning, participants who were presented with pictures that depicted the to-be-learned action words performed better initially (i.e., on the first set of words) than participants who were presented with pictures showing a different action. However, this difference between relevant and irrelevant picture conditions disappeared as learners gained more task experience (i.e., on later sets of words). Eye-tracking data suggested that the initial negative effect on learning disappeared because learners started to ignore the irrelevant pictures with task experience. Moreover, a subsequent study provided evidence that learners started to ignore the pictures based on their content, and not their location (Rop, Verkoeijen, & Van Gog, 2017).

However, because the extraneous information was pictorial and obviously irrelevant (i.e., it mismatched the verbal information that participants had to remember), it is an open question whether task experience would have similar effects when the extraneous information is textual (e.g., a text describing the elements of a picture) and unnecessary rather than irrelevant (i.e., in the sense that the information provided by the text is relevant for the learning task but not necessary as it can also be inferred from the picture). The present study addressed this question.

1.1 | Effects of extraneous information on learning

While learning from multimedia materials, that is, materials in which text (either spoken or written) and pictures (either static or dynamic) are combined (Mayer, 2014), a learner first has to select the relevant information from the text and picture (by attending to it). Subsequently, this information has to be organized into a coherent cognitive structure in working memory and has to be integrated with prior knowledge from long-term memory (Mayer, 2014). When either one of these processes (i.e., selection, organization, or integration) is disrupted, learning is hampered. The presentation of extraneous information in multimedia learning materials may hamper learning when it captures attention, because working memory capacity is limited (e.g., Baddeley, 2000; Cowan, 2001; Miller, 1956) and processing this extraneous information that is not conducive to learning reduces the working memory resources available for the selection, organization, and integration of information that is essential for learning.

The negative effect of extraneous information processing on learning has been demonstrated with a variety of materials and types of extraneous information and has been labelled the coherence principle (cf. Mayer & Fiorella, 2014) and/or the redundancy principle (cf. Kalyuga & Sweller, 2014). The coherence principle states that people learn more deeply from a multimedia message when unnecessary or irrelevant material is excluded rather than included. The redundancy principle suggests that presenting redundant material (e.g., the same information in two different formats, making one format unnecessary for learning) interferes with rather than facilitates learning. In effect, both principles entail that the presentation of extraneous information should be avoided, because it hampers learning compared to instructional materials in which this information has been eliminated. For instance, a negative effect of extraneous information on learning has been shown to occur when multimedia learning materials are enriched with interesting and entertaining information (i.e., seductive details; Harp & Mayer, 1998; Lehman, Schraw, McCrudden, & Hartly, 2007; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000; Rey, 2014; Sanchez & Wiley, 2006), when information on related systems is presented when learning about a specific system (Mayer, DeLeeuw, & Ayres, 2007), or when mismatching pictorial information is provided when learning word definitions (De Nooijer, Van Gog, Paas, & Zwaan, 2013; Hald, Van den Hurk, & Bekkering, 2015; Rop et al., 2018, 2017). Moreover, the effect has been demonstrated when text accompanying pictures or animation is presented in both spoken and written form (e.g., Craig, Gholson, & Driscoll, 2002; Mayer et al., 2001; but see Mayer & Johnson, 2008; Yue, Bjork, & Bjork, 2013), when self-containing diagrams are accompanied by textual explanations (Bobis, Sweller, & Cooper, 1993; Chandler & Sweller, 1991) and when unnecessary details and examples are added to learning materials (e.g., Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Reder & Anderson, 1982).

In all these studies, the extraneous information was either irrelevant or unnecessary, depending on its relation with the learning goal. Irrelevant information is unrelated to the learning goal and would adhere more to the coherence principle (e.g., seductive details, information about related systems, and mismatching information). Unnecessary information, on the other hand, is related to the learning goal, but not necessary for learning because the information is presented twice (e.g., the same spoken and written text accompanying an illustration, self-contained diagrams with unnecessary textual explanations) or is unnecessarily elaborate (e.g., unnecessary details and examples). The negative effect of unnecessary information therefore more closely resembles the redundancy principle and is addressed in the present study.

As mentioned above, both the coherence and the redundancy principle entail that presenting extraneous information hampers learning because it captures learners' attention, and learners spend valuable cognitive resources on processing this information that is not conducive to learning. However, recently, evidence emerged that people might learn to ignore extraneous information with increasing task experience.

1.2 | Task experience

Eye-tracking studies already showed that participants may learn to ignore task-irrelevant information as a consequence of task experience (Haider & Frensch, 1999) or explicit instruction (Canham & Hegarty, 2010; Hegarty, Canham, & Fabrikant, 2010), and the results of Rop et al. (2018) indicate that this effect can be generalized to learning with multimedia materials. Indeed, their results suggest that when learners gain more experience with the learning materials, they adapt their study strategy and start to ignore irrelevant information, thereby diminishing the negative effect of irrelevant information on learning. Thus, task experience may be a boundary condition for the negative effect of extraneous information on learning, because participants stop allocating attention to this information. It is important to establish potential boundary conditions as they describe the limits of generalizability of scientific theories (Busse, Kach, & Wagner, 2016; Whetten, 1989). However, as the extraneous information in the study by Rop et al. (2018; see also Rop et al., 2017) was pictorial, obviously irrelevant (i.e., it mismatched the verbal information that participants had to remember), and not integrated with other information (i.e., integrated extraneous information seems to hamper learning more; Chandler & Sweller, 1991), it is an open question whether task experience would have similar effects when the extraneous information is textual (e.g., a text describing the elements of a picture), unnecessary rather than irrelevant (i.e., in the sense that the information provided by the text is relevant for the learning task but not necessary as it can also be inferred from the picture), and integrated with relevant information (e.g., unnecessary text integrated with a picture).

There are several reasons why task experience might not have a similar effect (i.e., might not help students to learn to ignore extraneous information) under those circumstances. First, textual information may be harder to ignore than pictorial information as learners often focus more quickly and more strongly on text than on the associated pictures (Cromley, Snyder-Hogan, & Luciw-Dubas, 2010; Hannus & Hyönä, 1999; Schmidt-Weigand, Kohnert, & Glowalla, 2010). Second, unnecessary information might be harder to ignore than irrelevant information, as it is likely less obvious for learners that unnecessary information is extraneous to their learning process. Finally, whereas extraneous information that is presented separated from the relevant information might be relatively easy for participants to ignore, that might be more difficult when it is integrated with relevant information. The present study addressed these questions.

1.3 | The present study

The present study aimed to answer two questions: (a) Do students learn to ignore unnecessary textual information with increasing task experience, and (b) is the unnecessary textual information more difficult to ignore when it is integrated with relevant information? We conducted two experiments in which participants learned about the process of mitosis using a multimedia slideshow. The slides consisted of a text explaining the process of mitosis (relevant text), and a picture of the visuo-spatial appearance of the cell in that particular stage of mitosis. In two conditions, a description of the picture components (unnecessary text) was added to the slide, either separated from (separated condition; see Figure 1) or integrated in (integrated condition; see Figure 2) the pictorial information. The design of the integrated condition (i.e., text boxes that were integrated into the picture using lines) was similar to integrated conditions used in other studies on multimedia learning (e.g., Cierniak, Scheiter, & Gerjets, 2009; Mayer & Johnson, 2008) and allowed full processing of the picture. The textual information was relevant for the learning goals, but it was unnecessary as it provided a description of the picture, while a picture is generally a better representation of visuo-spatial content (Levie & Lentz, 1982; Schmidt-Weigand & Scheiter, 2011). In the third condition, only the relevant text and the picture were presented on the slide (control condition; see Figure 1). In this condition, we did not expect any effect of task experience on learning, as there was no information that could be ignored. However, this condition was added to assess whether the unnecessary text indeed led to lower learning outcomes.

Experiment 1 investigated, by measuring learning immediately after each slide, whether an initial negative effect of unnecessary information would occur; whether this negative effect would decrease (or even disappear) as participants gained task experience; and whether this decrease would be stronger when the unnecessary text was presented separated from the picture (i.e., separated unnecessary text would be easier to ignore than integrated unnecessary text). Because we expected that the processing of unnecessary information would increase cognitive load, participants were asked to rate how much mental effort they invested in learning the materials immediately after each slide (as an indicator of how much cognitive load participants experienced: Paas, Tuovinen, Tabbers, & Van Gerven, 2003). We also asked participants to rate how much mental effort they invested during the test phase after each slide, as participants who gained more knowledge during the learning phase should be able to attain higher test performance with less investment of mental effort (Van Gog & Paas, 2008). We expected that participants in the unnecessary-information conditions would initially invest more mental effort during the learning and test phase than participants in the control condition, while this difference should decrease (or even disappear) as participants gained task experience (at least in the separated condition). Experiment 2 was a direct replication of Experiment 1, apart from the fact that eye tracking was employed to directly study attention allocation processes.

2 | EXPERIMENT 1

2.1 | Method

2.1.1 | Participants and design

Initially, 96 individuals participated in the study, recruited via the university's online recruitment systems. Due to an error in one of

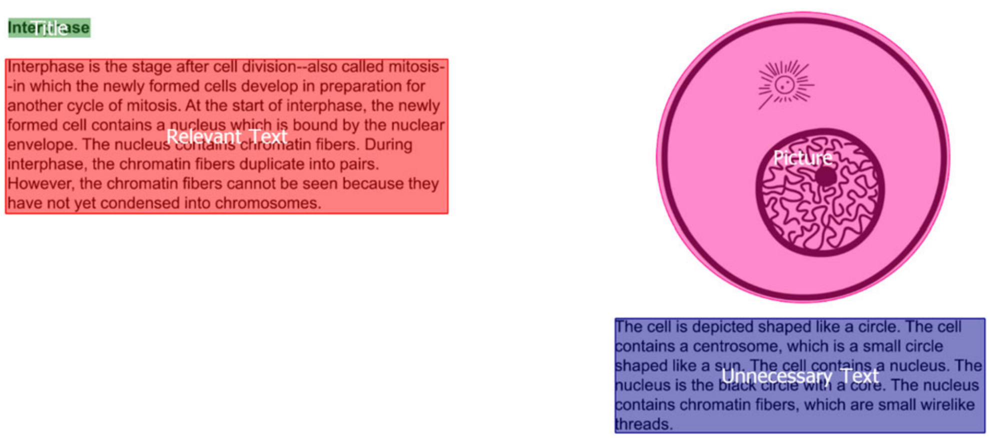

FIGURE 1 Example slide for the separated and control conditions with the areas of interest used in Experiment 2 (green: phase title, red: relevant text, pink: picture, and blue: unnecessary text). The description of the components in the picture (i.e., unnecessary text) is presented underneath the picture. In the control condition, this description is not present [Colour figure can be viewed at wileyonlinelibrary.com]

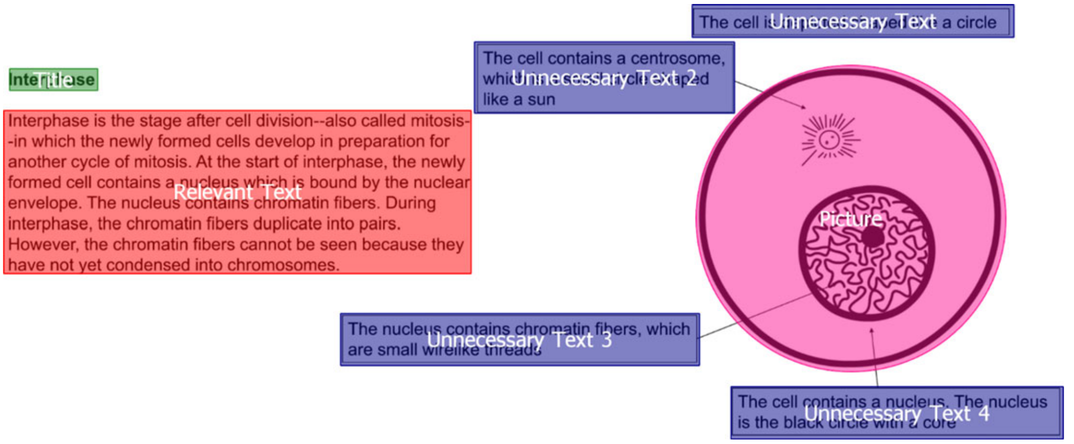

FIGURE 2 Example slide for the integrated condition with the areas of interest used in Experiment 2 (green: phase title; red: relevant text, pink: picture, and blue: unnecessary text). The description of the components in the picture is integrated in the picture [Colour figure can be viewed at wileyonlinelibrary.com]

those systems, it turned out that two participants had already graduated and therefore they were excluded from the sample. The final sample comprised 94 undergraduate students from a Dutch University (M_{age} = 21.74 years, *SD* = 2.55 years; 65 female), consisting of psychology students who participated for course credit (*n* = 37) or other students (mostly from the economic faculty) who participated for a financial compensation of 5 euro (*n* = 57). They were randomly assigned to one of the three conditions: control (*n* = 32), integrated (*n* = 31), and separated (*n* = 31).

2.1.2 | Materials

The materials were designed and presented using E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA).

Prior knowledge test

Participants' prior knowledge was tested with four multiple-choice questions about the process of mitosis (e.g., what is mitosis?) with four possible answers (e.g., the correct alternative: "A process in which the nucleus and duplicated chromosomes of a cell divide and are evenly distributed"). During this test, and all other tests used in this experiment, participants had to guess when they did not know an answer, as the program would not progress unless they answered a question.

Learning materials

The learning materials consisted of a slideshow in which six slides described and depicted the process of mitosis. During mitosis, the nucleus and chromosomes of a cell are duplicated and are divided over two new daughter cells. This process consists of six phases: interphase, prophase, prometaphase, metaphase, anaphase, and telophase. Each phase in the process was described on a separate slide, accompanied by a drawing depicting that phase. That the drawings were relevant for learning had been established in prior research with these learning materials, which showed that the expository text accompanied by pictures led to better learning outcomes than the text alone (Scheiter, Schüler, Gerjets, Huk, & Hesse, 2014; Schüler, Scheiter, & Gerjets, 2013).

On average, the relevant text consisted of 77 words on each slide (range 72–82), whereas the unnecessary text consisted of 39 words per slide (range 28–46). The location of the picture and the unnecessary text was varied (left- or right-hand side of the screen) between subjects to control for potential bias in attention as a result of reading direction. The learning materials were system-paced, and the available time was the same in each condition, so participants could not compensate for time spent on processing the unnecessary text by investing more time on the materials overall. A small user-paced pilot (*n* = 8) was used to determine the presentation time per slide. We calculated the average time those eight participants spent on each slide and used this as the presentation time of the corresponding slide in the current experiment (Slide 1: 65 s, Slide 2: 120 s, Slide 3: 110 s, Slide 4: 97 s, Slide 5: 107 s, and Slide 6: 77 s). It was not possible for participants to go back to a previously presented slide.

Cloze test

Knowledge about the studied mitosis phase was tested immediately after each slide, using a cloze test in which participants were presented with four short sentences from the relevant text they had just studied, with one or two keyword (s) omitted (e.g., The nucleus of the newly formed cell is bound by the __). Participants were asked to fill in the blanks by typing the correct answer into the answer box. To minimize the possibility that participants recognized that only their knowledge of the relevant text was tested, the sentences were all presented on a different slide and used slightly different wording on some occasions. For example, while the slide read: "The newly formed cell contains a nucleus which is bound by the nuclear envelope," the corresponding question was "The nucleus of the newly formed cell is bound by the __."

Invested mental effort

Participants were asked to indicate how much effort they invested in learning the content of each preceding slide on a 9-point rating scale (Paas, 1992), ranging from 1 (*extremely low effort*) to 9 (*extremely high effort*). Moreover, participants were asked to indicate how much effort they invested in answering the cloze test after each slide, using the same 9-point scale.

Picture test

Because processing the unnecessary text might have gone at the expense of processing the pictures, we also tested participants' knowledge of the pictures at the end of the experiment. To do so, we used a multiple-choice test consisting of seven items. In six items (present in a random order), participants were presented with a picture of one of the phases and had to choose which phase it depicted, from six alternatives. In the seventh item, participants saw all six phases depicted on the screen and had to indicate the correct order of the pictures (i.e., according to the phases of mitosis) from six possible answers.

2.1.3 | Procedure

Participants were tested either individually or with two participants simultaneously. First, the prior knowledge test was administered, and participants were asked to fill in their age and gender. After this test, participants learned about mitosis under one of the three conditions. After each slide, participants first had to indicate how much effort they invested in studying the preceding slide, then fill in the cloze test, and then indicate how much effort they invested in answering the cloze test questions. After the learning phase, participants had to fill in the picture test. In total, the experiment took approximately 20 to 30 min, and it was administered without breaks.

2.1.4 | Scoring

For all multiple-choice questions, participants received 1 point when they gave the correct answer and no points when they gave the wrong answer. Thus, participants could score a maximum of 4 points on the pretest, and 7 points on the picture test. For the cloze test questions, participants were awarded 1 point if the correct answer was given, 0.5 points when the answer was partially correct, and 0 points when they did not provide an answer or if it was completely wrong. Thus, participants could score 0 to 4 points per cloze test after each slide. A random subset of the cloze test data (10.4%) was scored by a second rater, and interrater reliability was high (κ = 0.91).

2.2 | Results

As mentioned in the materials section, we controlled for reading direction by counterbalancing the location of the picture and the unnecessary text (hereafter called PUT). As a check revealed that PUT location seemed to influence the dependent variables, we included it as a factor in the analyses. In the analyses of the effects of task experience (i.e., on cloze test performance and invested mental effort during learning and in the cloze test), we made the distinction between low (Slides 1 to 3) and high task experience (Slides 4 to 6).[1] When the sphericity assumption was violated, we report the results after Greenhouse–Geisser correction. We used partial eta-squared and Cohen's *d* as measures of effect size; both can be interpreted in terms of small (η_p^2 ~ 0.01, *d* ~ 0.2), medium (η_p^2 ~ 0.06, *d* ~ 0.5), and large (η_p^2 ~ 0.14, *d* ~ 0.8) effect sizes (Cohen, 1988). Moreover, when post hoc follow-up tests were performed, we used a Bonferroni correction (i.e., multiplying the *p* value with the number of tests performed).

[1]We took the midpoint to make the division between low and high task experience.

2.2.1 | Prior knowledge

We first estimated the Cronbach's alpha of the prior knowledge test (although it should be noted that this estimate has a high degree of imprecision because of the small sample it is based upon), which was relatively low, α = 0.28. This was to be expected as participants likely had low prior knowledge and as a result resorted to guessing. Performance on the prior knowledge test is presented in Table 1 and was analysed with a 3 × 2 analysis of variance (ANOVA) with condition (separated, integrated, or control) and PUT location (left or right) as between-subjects factors. The analyses revealed no effect of condition, $F < 1$, no effect of PUT location, $F(1, 88) = 3.00$, $p = 0.087$, $\eta_p^2 = 0.03$, and no interaction, $F(2, 88) = 1.81$, $p = 0.169$, $\eta_p^2 = 0.04$. Hence, there were no significant differences in prior knowledge among conditions.

2.2.2 | Cloze test

We also estimated the Cronbach's alpha for the cloze test, which was relatively high (α = 0.80). The average performance on the first three (low task experience) and last three cloze tests (high task experience) is presented in Table 2. We performed a 3 × 2 × 2 mixed ANOVA with between-subjects factors condition (separated, integrated, or control) and PUT location (left or right) and within-subjects factor task experience (low or high) on these data. The analysis revealed a main effect of condition, $F(2, 88) = 5.06$, $p = 0.008$, $\eta_p^2 = 0.10$, with follow-up tests showing that performance in the separated condition ($M = 1.19$, $SD = 0.62$) was significantly lower than performance in the control condition ($M = 1.71$, $SD = 0.65$), $p = 0.005$, $d = 0.82$. Performance in the integrated condition ($M = 1.45$, $SD = 0.64$) did not significantly differ from performance in the control condition, $p = 0.349$, $d = 0.39$, or the separated condition $p = 0.319$, $d = 0.42$. Moreover, the analysis revealed a main effect of task experience, $F(1, 88) = 10.20$, $p = 0.002$, $\eta_p^2 = 0.10$, indicating that cloze test performance was higher on the first three slides, when participants had less task experience ($M = 1.55$, $SD = 0.74$), than on the last three slides, when they had more task experience ($M = 1.36$, $SD = 0.74$). We found no main

TABLE 1 Mean (and *SD*) performance on the prior knowledge test (max. = 4) and picture test (max. = 7) as a function of condition and PUT location in Experiments 1 and 2

		Prior knowledge test		Picture test	
		Exp. 1	Exp. 2	Exp. 1	Exp. 2
PUT left	Control	2.76 (1.09)	2.26 (1.10)	4.59 (1.77)	4.89 (1.70)
	Integrated	2.19 (0.98)	2.50 (1.05)	4.69 (1.82)	4.95 (1.79)
	Separated	2.80 (1.08)	2.23 (1.23)	4.67 (1.99)	5.32 (1.43)
	Total	2.58 (1.07)	2.33 (1.12)	4.65 (1.82)	5.07 (1.62)
PUT right	Control	2.13 (1.13)	2.37 (0.96)	4.07 (1.22)	5.79 (1.44)
	Integrated	2.40 (1.06)	2.55 (1.19)	5.20 (2.01)	5.40 (1.64)
	Separated	2.06 (1.12)	2.41 (1.14)	4.81 (1.56)	5.23 (1.66)
	Total	2.20 (1.09)	2.44 (1.09)	4.70 (1.66)	5.46 (1.58)
Total	Control	2.47 (1.14)	2.32 (1.02)	4.34 (1.54)	5.34 (1.62)
	Integrated	2.29 (1.01)	2.53 (1.11)	4.94 (1.90)	5.18 (1.71)
	Separated	2.42 (1.15)	2.32 (1.18)	4.74 (1.75)	5.27 (1.53)
	Total	2.39 (1.09)	2.39 (1.10)	4.67 (1.73)	5.26 (1.60)

Note. PUT: picture and unnecessary text.

TABLE 2 Mean (and *SD*) cloze test performance (max. = 4) as a function of condition, PUT location, and task experience in Experiments 1 and 2

		Experiment 1 Task experience		Experiment 2 Task experience	
		Low	High	Low	High
PUT left	Control	1.72 (0.71)	1.76 (0.69)	1.48 (0.64)	1.31 (0.70)
	Integrated	1.48 (0.71)	1.67 (0.77)	1.43 (0.65)	1.38 (0.71)
	Separated	1.30 (0.74)	1.09 (0.73)	1.50 (0.50)	1.39 (0.59)
	Total	1.51 (0.73)	1.52 (0.78)	1.47 (0.59)	1.36 (0.66)
PUT right	Control	2.02 (0.72)	1.32 (0.75)	1.58 (0.83)	1.34 (1.06)
	Integrated	1.48 (0.72)	1.18 (0.61)	1.29 (0.73)	1.32 (0.61)
	Separated	1.28 (0.66)	1.09 (0.64)	1.56 (0.77)	1.60 (0.87)
	Total	1.59 (0.75)	1.20 (0.66)	1.48 (0.77)	1.43 (0.86)
Total	Control	1.86 (0.72)	1.56 (0.74)	1.53 (0.73)	1.32 (0.89)
	Integrated	1.48 (0.70)	1.43 (0.73)	1.36 (0.69)	1.35 (0.66)
	Separated	1.29 (0.69)	1.09 (0.67)	1.53 (0.64)	1.50 (0.74)
	Total	1.55 (0.74)	1.36 (0.74)	1.47 (0.69)	1.39 (0.76)

Note. PUT: picture and unnecessary text.

effect of PUT location, $F < 1$, but the analysis did reveal an interaction between task experience and PUT location, $F(1, 88) = 11.11$, $p = 0.001$, $\eta_p^2 = 0.11$. Two-tailed independent samples *t* tests showed that the location of the unnecessary information (left, $M = 1.51$, $SD = 0.73$; right, $M = 1.59$, $SD = 0.75$) did not influence cloze test performance when participants had low task experience, $t(92) = 0.53$, $p > 0.999$, $d = 0.11$, whereas participants with more task experience seemed to perform better when the unnecessary text was presented left ($M = 1.52$, $SD = 0.78$) than when it was presented right ($M = 1.20$, $SD = 0.66$), $t(92) = 2.18$, $p = 0.064$, $d = 0.45$. We found no interaction between PUT location and condition, $F < 1$. More relevant for our hypotheses, we found no interaction between task experience and condition, $F(2, 88) = 1.65$, $p = 0.198$, $\eta_p^2 = 0.04$. However, we did find a small three-way interaction between condition, task experience, and PUT location, $F(2, 88) = 3.51$, $p = 0.034$, $\eta_p^2 = 0.07$. This three-way interaction presumably arose because initial performance differences between the control and separated conditions diminished when participants gained task experience, but only when the unnecessary information was presented on the right-hand side of the screen (see Figure 3). We did no predict this three-way interaction based on our theoretical framework, and the pattern of results was not in line with it. This is because performance in the control condition diminished while reasoning from our theoretical framework one would predict the performance level to remain constant in the control condition, whereas it ought to increase in the separated condition.

2.2.3 | Mental effort

Self-reported invested mental effort during the learning phase and the cloze test are presented in Tables 3 and 4. We performed 3 × 2 × 2 mixed ANOVAs with between-subjects factors condition (separated, integrated, or control) and PUT location (left or right) and within-subjects factor task experience (low or high) on the invested mental effort data obtained during the learning phase and the cloze test. For the invested mental effort during the learning phase, this analysis revealed no main effect of condition, $F < 1$, and no main effect of PUT location, $F(1, 88) = 2.41$, $p = 0.124$, $\eta_p^2 = 0.03$. The analysis did reveal a small main effect of task experience, $F(1, 88) = 6.16$, $p = 0.015$, $\eta_p^2 = 0.07$, indicating that participants invested more mental effort when they had lower task experience, ($M = 6.73$, $SD = 1.09$), than when they had more task experience, ($M = 6.52$, $SD = 1.21$). There were no significant interactions, all Fs < 1.

For the invested mental effort during the cloze test, this analysis revealed no main effect of condition, $F < 1$, no main effect of PUT location, $F(2, 88) = 1.82$, $p = 0.181$, $\eta_p^2 = 0.02$, and no main effect of task experience, $F < 1$. The analysis revealed no interaction between PUT location and condition, $F(2, 88) = 2.29$, $p = 0.107$, $\eta_p^2 = 0.05$, PUT location and task experience, $F(2, 88) = 1.93$, $p = 0.168$, $\eta_p^2 = 0.02$, task experience and condition, $F < 1$, nor a three-way interaction condition × PUT location × task experience, $F(2, 88) = 1.15$, $p = 0.323$, $\eta_p^2 = 0.03$.

2.2.4 | Picture test

Performance on the picture test is shown in Table 1 and was analysed with a 3 × 2 ANOVA with condition (separated, integrated, or control) and PUT location (left or right) as between-subjects factors. The analysis revealed no effect of condition, $F(2, 88) = 1.02$, $p = 0.366$, $\eta_p^2 = 0.02$, no effect of PUT location, $F < 1$, nor an interaction effect, $F < 1$.

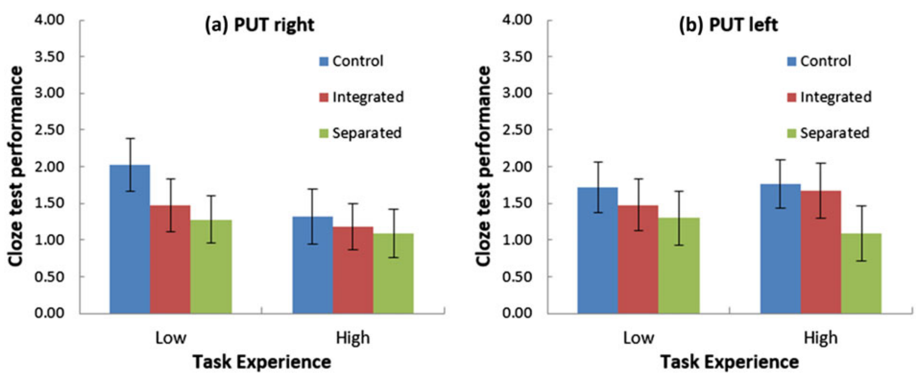

FIGURE 3 Mean cloze test performance in Experiment 1 (max. = 4) as a function of condition and task experience, when the picture and the unnecessary text (PUT) location was right (Figure 3a) or left (Figure 3b) [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Mean (and *SD*) invested mental effort (max. = 9) during the learning phase as a function of condition, PUT location, and task experience in Experiments 1 and 2

		Experiment 1 Task experience		Experiment 2 Task experience	
		Low	High	Low	High
PUT left	Control	7.00 (0.89)	6.86 (1.17)	6.58 (1.05)	6.61 (1.36)
	Integrated	6.88 (1.11)	6.80 (1.11)	6.40 (1.16)	6.10 (1.24)
	Separated	6.78 (0.72)	6.47 (0.88)	6.15 (1.05)	6.09 (1.03)
	Total	6.89 (0.91)	6.72 (1.06)	6.37 (1.08)	6.26 (1.22)
PUT right	Control	6.62 (0.77)	6.47 (1.27)	6.60 (1.09)	6.19 (1.21)
	Integrated	6.44 (1.52)	6.07 (1.62)	6.50 (1.24)	6.30 (1.39)
	Separated	6.65 (1.36)	6.44 (1.17)	6.58 (0.89)	6.45 (0.85)
	Total	6.57 (1.24)	6.33 (1.34)	6.56 (1.06)	6.32 (1.15)
Total	Control	6.82 (0.85)	6.68 (1.21)	6.59 (1.05)	6.40 (1.29)
	Integrated	6.67 (1.32)	6.44 (1.40)	6.45 (1.18)	6.20 (1.30)
	Separated	6.71 (1.08)	6.45 (1.02)	6.36 (0.99)	6.27 (0.95)
	Total	6.73 (1.09)	6.52 (1.21)	6.46 (1.07)	6.29 (1.18)

Note. PUT: picture and unnecessary text.

TABLE 4 Mean (and *SD*) Invested mental effort (max. = 9) during the cloze test as a function of condition, PUT location, and task experience in Experiments 1 and 2

		Experiment 1 Task experience		Experiment 2 Task experience	
		Low	High	Low	High
PUT left	Control	6.88 (1.25)	6.86 (1.17)	6.26 (1.39)	6.37 (1.46)
	Integrated	6.90 (0.84)	6.89 (0.84)	5.77 (1.21)	5.62 (1.18)
	Separated	6.02 (1.07)	6.02 (1.06)	5.91 (1.46)	5.82 (1.07)
	Total	6.62 (1.12)	6.72 (1.06)	5.97 (1.36)	5.92 (1.26)
PUT right	Control	6.04 (1.01)	6.47 (1.27)	5.98 (1.09)	5.74 (1.11)
	Integrated	6.09 (1.46)	6.09 (1.46)	6.02 (1.39)	6.08 (1.45)
	Separated	6.40 (1.30)	6.44 (1.27)	6.05 (1.05)	5.98 (0.98)
	Total	6.18 (1.25)	6.33 (1.34)	6.02 (1.16)	5.94 (1.18)
Total	Control	6.49 (1.21)	6.68 (1.21)	6.12 (1.24)	6.05 (1.32)
	Integrated	6.51 (1.23)	6.44 (1.40)	5.89 (1.29)	5.85 (1.32)
	Separated	6.22 (1.19)	6.45 (1.02)	5.98 (1.26)	5.90 (1.02)
	Total	6.40 (1.20)	6.52 (1.21)	5.99 (1.26)	5.93 (1.21)

Note. PUT: picture and unnecessary text.

2.3 | Discussion

Surprisingly, we did not find a consistent negative effect of unnecessary information on (initial) learning. Unnecessary information only had a negative effect on cloze test performance when it was presented separated from the relevant information, not when it was integrated. This unexpected finding may be due to a combination of a negative effect of unnecessary information and a kind of split-attention effect (as the integrated condition, without the need to split attention between the PUT, scored in between the control and separated conditions). Indeed, the split-attention effect states that learning is hampered when mutually referring information sources that are both essential for learning are presented separately, compared with when they are physically integrated (Ayres & Sweller, 2014). Although the sources of information in the present study were not both essential for learning, it was also not immediately apparent that the added textual information was not essential to the learning goal. Therefore, our participants might still have attempted to integrate the unnecessary information with the essential information (at least during the first few phases), which led to unnecessary visual search in the separated condition.

The main effect of separated unnecessary text was qualified by a three-way interaction between condition, task experience, and PUT location, suggesting that initial performance differences between the control and separated condition diminished when participants gained task experience, but only when the unnecessary information was presented on the right-hand side of the screen. In contrast to our expectations, however, the reduced difference between the conditions seemed to result from a decline in performance in the control condition rather than an increase in performance in the separated condition. In sum, our hypotheses regarding task experience were not confirmed in Experiment 1. To get more insight into how students process the unnecessary text, whether the separated condition leads to unnecessary visual search, and whether this changes over time (i.e., with increasing task experience), Experiment 2 replicated Experiment 1, using eye-tracking methodology.

3 | EXPERIMENT 2

In Experiment 2, we employed eye tracking to investigate how much attention participants devoted to the unnecessary information in the separated and integrated conditions and whether they would start to ignore it over time. We hypothesized that the unnecessary text would initially attract attention, but with increasing task experience, participants would start to ignore the unnecessary text and allocate less attention to it, especially in the separated condition. This should result in (a) shorter fixation duration on the unnecessary text and longer fixation duration on the relevant text and picture with increasing task experience; and (b) more transitions between relevant information sources and less transitions between relevant and unnecessary information sources with increasing task experience.

3.1 | Method

3.1.1 | Participants and design

Participants were 133 German University students (M_{age} = 21.28 years, *SD* = 2.34 years; 107 female) who participated for course credit or a small fee of 5 euro. All participants had normal or corrected-to-normal vision. One participant indicated after completing the experiment that s/he wanted to retract his/her data. For six participants, the data on how long they spend on each slide indicated that they had skipped parts of the learning phase. Furthermore, due to a randomization error, four participants participated in two conditions of the Experiment (i.e., they saw each slide twice, in two different conditions). The data of these 11 participants were excluded from all future analyses, resulting in a sample of 122 participants (M_{age} = 21.06 years, *SD* = 2.28 years; 98 female). Participants were randomly assigned to one of the three conditions: control (*n* = 38), separated (*n* = 44), and integrated (*n* = 40). Again, within conditions, PUT location was varied: For half of the participants, the PUT was presented at the right, whereas for the other half, the PUT was presented at the left.

3.1.2 | Apparatus and materials

The materials were identical to those of Experiment 1. The materials were presented in SMI Experiment Center (Version 3.6; SensoMotoric Instruments), on a monitor with a resolution of 1920 × 1080 pixels. Participants' eye movements were recorded using SMI RED 250 Mobile eye trackers (SensoMotoric Instruments) that record binocularly at 250 Hz using SMI iView software (Version 2.8; SensoMotoric Instruments). The data were subsequently analysed using BeGaze software (Version 3.7; SensoMotoric Instruments).

3.1.3 | Procedure

The procedure was similar to that of Experiment 1, only in Experiment 2 participants were tested individually, or in groups of up to three participants simultaneously, and their eye movements were recorded during the learning phase. At the start of the experiment, participants were seated in front of a mobile eye tracker, with their head approximately 60 cm from the monitor. After a short introduction and the prior knowledge test, the eye tracker was calibrated using a 13-point calibration plus 4-point validation procedure, and participants were instructed to move as little as possible (although they were allowed to move somewhat). The experiment lasted around 20 min and was administered without breaks.

3.1.4 | Data analysis

For the eye tracking analyses, we first checked the accuracy of calibration, which was sufficient for all participants (i.e., no deviations from the four validation points of more than 1° visual angle). We then checked the tracking ratio (i.e., the percentage of time for which the eye tracker actually measured the eye movements) for each participant. We had to exclude 22 participants (control: n = 8; separated: n = 5; integrated n = 9) because their tracking ratio was below 70%. The final sample (n = 100) had an average tracking ratio of 92.03% (SD = 6.75%), with a mean calibration accuracy of 0.28° (SD = 0.15°) and was distributed across the conditions as follows: control (n = 30), separated (n = 39), and integrated (n = 31).

For the eye-tracking analyses, we defined fixations using a 40°/s velocity threshold and a minimal duration of 100 ms (cf. Holmqvist et al., 2011). On each slide in each condition, we created areas of interest (AoIs) for the picture, for the relevant text, and for the title (see Figure 1). In the separated condition, we defined one extra AoI for the unnecessary text (see Figure 1), whereas in the integrated condition, we created additional AoIs for each text block (see Figure 2). In this condition, in the first three phases, there were four unnecessary text blocks, whereas the slides in the last three phases had three unnecessary text blocks.

As a measure of attention to the different AoIs, we used fixation time. Because presentation time between slides was different (see the Learning materials section of Experiment 1), and the size of the AoIs was different between conditions (see Figures 1 and 2), we had to calculate a relative measure of fixation time. We did so by dividing the fixation time on each AoI by the percentage of the screen covered by that AoI to control for the size of the AoI. We then divided this value by the total fixation time on that slide in seconds (i.e., the sum of all fixations on the different AoIs and white space), to control for the differences in presentation duration and tracking ratio.

To measure integration of the different sources of information (i.e., relevant text, picture, unnecessary text), we used transitions between the different AoIs. We defined three types of transitions: relevant-picture transitions, which are transitions between the picture and relevant text and vice versa; unnecessary-relevant transitions, which are transitions between the unnecessary and relevant text and vice versa; and unnecessary-picture transitions, which are transitions between the unnecessary text and the picture and vice versa. The unnecessary-relevant and unnecessary-picture transitions can only be calculated for the two unnecessary text conditions. To control for differences in presentation duration between slides, we divided the number of transitions by the total fixation time on that slide in seconds (i.e., the same value we used in the fixation time measure).

3.2 | Results

The data on prior knowledge, cloze test performance, invested mental effort, and picture test performance are analysed with the same ANOVAs as in Experiment 1.

3.2.1 | Prior knowledge

Cronbach's alpha of the prior knowledge test was again relatively low, α = 0.21, and performance on this test is presented in Table 1. The analysis revealed no effect of condition, $F < 1$, no effect of PUT location, $F < 1$, nor an interaction, $F < 1$.

3.2.2 | Cloze test

Cronbach's alpha of the cloze test was again relatively high, α = 0.80. On the cloze test performance (see Table 3), the analyses revealed no main effect of condition, $F < 1$, no main effect of PUT location, $F < 1$, and no main effect of task experience, $F(2, 116) = 2.50$, $p = 0.116$, $\eta_p^2 = 0.02$. Furthermore, we found no interaction between condition and task experience, $F(2, 116) = 1.35$, $p = 0.262$, $\eta_p^2 = 0.02$, between task experience and PUT location, $F < 1$, or between condition and PUT location, $F < 1$. Finally, we did not find any evidence for the three-way interaction observed in Experiment 1, $F < 1$.

3.2.3 | Invested mental effort

The invested mental effort during learning is presented in Table 3. The analysis revealed no main effect of condition, $F < 1$, and no main effect of PUT location, $F < 1$. However, we did find a small main effect of task experience, $F(2, 116) = 4.45$, $p = 0.037$, $\eta_p^2 = 0.04$, indicating that invested mental effort during learning was higher on the first three slides, when participants had less task experience (M = 6.46, SD = 1.07) than on the last three slides when they had more task experience (M = 6.29, SD = 1.18). We found no interactions, all Fs < 1.

The analysis on the invested mental effort during the cloze test (see Table 4) revealed no main effect of condition, $F < 1$, no main effect of PUT location, $F < 1$, and no main effect of task experience, $F < 1$. Furthermore, we found no interactions between condition and task experience, $F < 1$, between PUT location and task experience, $F < 1$, between condition and PUT location, $F(2, 116) = 1.27$, $p = 0.258$, $\eta_p^2 = 0.02$, nor a three-way interaction, $F(2, 116) = 1.16$, $p = 0.317$, $\eta_p^2 = 0.02$.

3.2.4 | Picture test

Regarding the picture test (see Table 1), the analysis showed no effect of condition, $F < 1$, no effect of PUT location, $F(2, 116) = 2.04$, $p = 0.156$, $\eta_p^2 = 0.02$, or an interaction, $F < 1$.

3.2.5 | Eye movement data

The eye movement data were analysed in two steps. First, we tested whether the presence and layout of unnecessary information leads to differences in attention towards unnecessary and relevant information. Second, we tested whether the presence and layout of unnecessary information would lead to differences in integration of text and pictures. To do so, we performed a 3 × 2 × 2 mixed ANOVA with between-subjects factors condition (separated, integrated, or control) and PUT location (left or right) and within-subjects factor task experience (low or high) on the fixation time on the relevant text and the picture. On the fixation time on the unnecessary text, we performed a 2 × 2 × 2 mixed ANOVA with between-subjects factors condition (separated or integrated) and PUT location (left or right) and within-subjects factor task experience (low or high). The data on the relevant-picture, unnecessary-picture, and unnecessary-relevant transitions are analysed with nonparametric tests as the assumptions of normality were violated.

Fixation time

The data on the fixation time (corrected for AoI size and total fixation time, see Section 6.1.4) on the *unnecessary text* are presented in Table 5. The analysis revealed a significant main effect of condition, $F(1, 66) = 21.14$, $p < 0.001$, $\eta_p^2 = 0.24$, indicating that participants in the integrated condition ($M = 17.57$, $SD = 7.80$) spent less time fixating on the unnecessary text than participants in the separated condition ($M = 28.62$, $SD = 11.53$). Moreover, the analysis revealed a significant effect of task experience, $F(1, 66) = 6.98$, $p = 0.010$, $\eta_p^2 = 0.10$, indicating that participants spent less time fixating on the unnecessary text on the last three slides, after they gained task experience ($M = 21.84$, $SD = 14.59$), compared with on the first three slides, when they had lower task experience ($M = 25.60$, $SD = 11.30$). The analysis showed no effect of PUT location, $F(1, 66) = 3.58$, $p = 0.063$, $\eta_p^2 = 0.05$, and no interaction effects, smallest $p = 0.056$, $\eta_p^2 = 0.05$.

For the fixation time on the *relevant text* (see Table 5), our analysis revealed a significant main effect of condition, $F(2, 94) = 31.93$, $p < 0.001$, $\eta_p^2 = 0.41$. Follow-up tests showed that participants in the integrated condition ($M = 49.31$, $SD = 7.56$; $p < 0.001$, $d = 1.81$) and separated condition ($M = 50.20$, $SD = 7.51$; $p < 0.001$, $d = 1.68$) fixated less on the relevant text than participants in the control condition ($M = 61.90$, $SD = 6.33$). Time spent fixating on the relevant text did not differ significantly between the integrated and separated conditions, $p > 0.999$, $d = 0.12$. We found a significant effect of task experience, $F(2, 94) = 40.56$, $p < 0.001$, $\eta_p^2 = 0.30$, indicating that participants spent more time fixating the relevant text after they gained task experience ($M = 56.40$, $SD = 10.26$), compared with when they had lower task experience ($M = 50.46$, $SD = 10.11$). Furthermore, the analysis revealed a main effect of PUT location, $F(2, 94) = 17.47$, $p < 0.001$, $\eta_p^2 = 0.16$, indicating that participants attended more to the relevant text when the PUT was on the left ($M = 56.64$, $SD = 8.44$) than when it was on the right side of the screen ($M = 50.48$, $SD = 8.64$). There were no interaction effects, smallest $p = 0.070$, $\eta_p^2 = 0.06$.

Regarding the fixation time on the *picture* (see Table 5), we found no significant effect of condition, $F(2, 94) = 1.69$, $p = 0.189$, $\eta_p^2 = 0.04$, or task experience, $F(2, 94) = 1.67$, $p = 0.200$, $\eta_p^2 = 0.02$. However, the analysis revealed a main effect of PUT location, $F(2, 94) = 8.11$, $p = 0.005$, $\eta_p^2 = 0.08$, indicating that participants fixated more on the picture when the PUT was presented on the right ($M = 6.77$, $SD = 3.12$) than when it was presented on the left side of the screen ($M = 5.14$, $SD = 2.98$). The analyses revealed no interactions, smallest $p = 0.116$, $\eta_p^2 = 0.05$.

TABLE 5 Mean (and *SD*) fixation duration on the different areas of interest as a function of condition, PUT location, and task experience

		Unnecessary text Task experience		Relevant text Task experience		Picture Task experience	
		Low	High	Low	High	Low	High
PUT left	Control			63.63 (6.90)	66.02 (6.02)	5.09 (3.45)	5.91 (4.86)
	Integrated	17.49 (4.79)	13.63 (9.13)	49.44 (5.99)	57.64 (8.99)	5.43 (2.81)	4.87 (2.99)
	Separated	30.60 (11.87)	20.82 (14.18)	46.41 (7.54)	57.12 (9.27)	4.69 (2.67)	4.93 (3.23)
	Total	24.86 (11.43)	17.68 (12.58)	53.03 (10.23)	60.24 (9.06)	5.04 (2.94)	5.24 (3.74)
PUT right	Control			56.92 (7.28)	60.17 (7.37)	7.74 (3.26)	7.47 (4.10)
	Integrated	20.52 (10.65)	17.92 (8.54)	42.83 (8.40)	48.80 (9.04)	6.41 (3.09)	8.33 (3.98)
	Separated	30.85 (9.81)	31.37 (17.16)	46.46 (7.61)	51.27 (10.27)	5.50 (3.63)	5.98 (3.11)
	Total	26.23 (11.32)	25.36 (15.38)	48.09 (9.49)	52.86 (10.10)	6.40 (3.42)	7.15 (3.75)
Total	Control			60.50 (7.74)	63.29 (7.20)	6.33 (3.57)	6.63 (4.51)
	Integrated	19.15 (8.53)	15.99 (8.93)	45.82 (8.02)	52.79 (9.93)	5.97 (2.96)	6.77 (3.92)
	Separated	30.73 (10.66)	26.50 (16.53)	46.44 (7.48)	53.97 (10.13)	5.12 (3.21)	5.50 (3.17)
	Total	25.60 (11.30)	21.84 (14.59)	50.46 (10.11)	56.40 (10.26)	5.75 (3.26)	6.23 (3.85)

Note. PUT: picture and unnecessary text.

Transitions

On the *unnecessary-picture transitions* (i.e., transitions between the unnecessary text and the picture; see Table 6), a Mann–Whitney test revealed a main effect of condition, $U = 314.00$, $p = 0.001$, indicating that participants in the integrated condition (*Mdn* = 0.11, *Range* = 0.34) made more unnecessary-picture transitions than participants in the separated condition (*Mdn* = 0.06, *Range* = 0.34). A Wilcoxon Signed Ranks test showed a significant effect of task experience, $Z = 4.75$, $p < 0.001$, indicating that participants made fewer unnecessary-picture transitions after they gained task experience (*Mdn* = 0.07, *SD* = 0.49) than when they had little task experience (*Mdn* = 0.11, *Range* = 0.52). Finally, a Mann–Whitney test revealed no effect of PUT location, $U = 558.00$, $p = 0.556$.

Regarding the *unnecessary-relevant transitions* (i.e., transitions between the unnecessary text and the relevant text; see Table 6), the analysis revealed a main effect of condition, $U = 353.00$, $p = 0.003$, indicating that participants in the integrated condition (*Mdn* = 0.021, *Range* = 0.07) made more unnecessary-relevant transitions than participants in the separated condition (*Mdn* = 0.013, *Range* = 0.13). We again found a main effect of task experience, $Z = 3.64$, $p < 0.001$, indicating that participants made fewer unnecessary-relevant transitions after they gained task experience (*Mdn* = 0.013, *Range* = 0.10) than when they had lower task experience (*Mdn* = 0.018, *Range* = 0.16). Furthermore, the analysis revealed a main effect of PUT location, $U = 301.00$, $p < 0.001$, showing that participants made more unnecessary-relevant transitions when the PUT was presented at the right (*Mdn* = 0.023, *Range* = 0.13) than when it was presented at the left (*Mdn* = 0.011, *Range* = 0.04).

Regarding the *relevant-picture transitions* (i.e., transitions between the relevant text and the picture; see Table 6), a Kruskall–Wallis test revealed a significant effect of condition, $\chi^2(2) = 11.56$, $p = 0.003$. Follow-up Mann–Whitney tests showed that both participants in the integrated (*Mdn* = 0.05, *Range* = 0.45; $U = 247.00$, $p = 0.006$) and separated conditions (*Mdn* = 0.07, *Range* = 0.39; $U = 359.00$, $p = 0.018$) made significantly fewer relevant-picture transitions than participants in the control condition (*Mdn* = 0.12, *Range* = 0.40). Participants in the integrated and separated conditions did not differ in the number of relevant-picture transitions, $U = 549.00$, $p > 0.999$. We found a significant effect of task experience, $Z = 3.36$, $p = 0.001$, indicating that participants made more relevant-picture transitions after they gained task experience (*Mdn* = 0.09, *Range* = 0.79), compared with when they had lower task experience (*Mdn* = 0.07, *Range* = 0.51). Finally, the analysis revealed an effect of PUT location, $U = 904.00$, $p = 0.018$, showing that participants made more relevant-picture transitions when the PUT was presented at the right (*Mdn* = 0.09, *Range* = 0.45) than when it was presented at the left (*Mdn* = 0.5, *Range* = 0.37).

3.3 | Discussion

The results of Experiment 2 are mixed. Although the eye-tracking measures supported our hypotheses, indicating that attention towards the unnecessary text waned with increasing task experience, this did not affect cloze test performance. More surprisingly, it seems that unnecessary text attracts less attention (as measured by fixation time) when it is integrated than when it is separated, although integrated unnecessary text leads to more integration attempts (as measured by transitions). It might have been more easy for participants to identify the function of the unnecessary text when it is integrated than when it is separated, leading to more attention towards the separated text. At the same time, the decreased spatial distance might have induced more integration attempt when the unnecessary text is integrated (cf. Ballard, Hayhoe, & Pelz, 1995; Gray & Fu, 2004). It should be noted that, although these differences are statically significant, the actual differences are quite small on some occasions. In contrast to our hypothesis, presentation of unnecessary text did not initially hamper learning about the process of mitosis, regardless of whether the unnecessary text was presented integrated in, or separated from the picture. Because we found no initial negative effect of the unnecessary text on learning, the question of whether task experience would reduce or eliminate that negative effect could not be answered.

Next to the main finding of diminishing attention to the unnecessary text in favour of attention to the essential textual information, the eye-tracking analyses suggested an effect of screen location of

TABLE 6 Median (and range) number of transitions between the different areas of interest as a function of condition, PUT location, and task experience

		Relevant-picture Task experience		Unnecessary-picture Task experience		Unnecessary-relevant Task experience	
		Low	High	Low	High	Low	High
PUT left	Control	0.12 (0.44)	0.11 (0.45)				
	Integrated	0.03 (0.09)	0.04 (0.25)	0.11 (0.19)	0.07 (0.16)	0.018 (0.03)	0.012 (0.05)
	Separated	0.03 (0.35)	0.05 (0.25)	0.11 (0.52)	0.05 (0.13)	0.008 (0.05)	0.000 (0.03)
	Total	0.04 (0.47)	0.05 (0.46)	0.11 (0.52)	0.06 (0.18)	0.012 (0.05)	0.009 (0.05)
PUT right	Control	0.13 (0.29)	0.11 (0.69)				
	Integrated	0.08 (0.49)	0.11 (0.78)	0.13 (0.20)	0.10 (0.48)	0.034 (0.11)	0.018 (0.08)
	Separated	0.08 (0.38)	0.07 (0.40)	0.07 (0.42)	0.07 (0.26)	0.016 (0.16)	0.016 (0.10)
	Total	0.08 (0.51)	0.10 (0.78)	0.10 (0.42)	0.08 (0.49)	0.025 (0.16)	0.017 (0.10)
Total	Control	0.12 (0.44)	0.11 (0.75)				
	Integrated	0.05 (0.51)	0.06 (0.79)	0.12 (0.20)	0.08 (0.48)	0.024 (0.11)	0.017 (0.08)
	Separated	0.06 (0.38)	0.06 (0.42)	0.08 (0.52)	0.07 (0.26)	0.010 (0.16)	0.009 (0.10)
	Total	0.07 (0.51)	0.09 (0.79)	0.11 (0.52)	0.07 (0.49)	0.018 (0.16)	0.013 (0.10)

the unnecessary text and picture. When the relevant text was on the right-hand side of the screen (and the picture + unnecessary text on the left), participants attended more to it than when it was on the left-hand side of the screen. A possible explanation is that this might be due to the fact that participants looked at the *centre* of the screen at the beginning of each new slide because the mental effort question on the preceding slide was presented in the centre. When attention is centrally located, one may be inclined (because of Western reading direction) to process information on the right-hand side of the screen first. However, this explanation makes the implicit assumption that participants directly attend to (relevant) information on a new slide, without first making a saccade from the centre to the (top)-left part of the screen, and is therefore speculative. Future research should replicate these findings before any theoretical or practical conclusions can be drawn.

4 | GENERAL DISCUSSION

According to well-known principles in multimedia learning, the presentation of extraneous information (i.e., irrelevant or unnecessary) should be avoided, because it hinders learning. These are the coherence principle (cf. Harp & Mayer, 1998; Mayer & Fiorella, 2014) and the redundancy principle (cf. Chandler & Sweller, 1991; Kalyuga & Sweller, 2014). Although the coherence principle mostly entails the negative effect of irrelevant information (not related to the learning goal), the redundancy principle mostly concerns the negative effect of unnecessary information (related to the learning goal, but not necessary for learning). Recent research with irrelevant pictorial information demonstrated that students may learn to ignore such information when they gain experience with the task, at which point it no longer negatively affects their learning (Rop et al., 2018). The present study aimed to examine whether these findings would extend to extraneous information that is textual and unnecessary rather than irrelevant. Moreover, we investigated the role of the layout of the unnecessary textual information: We expected that it would be harder for students to (learn to) ignore unnecessary text when it is presented spatially integrated in a relevant picture, as compared with spatially separated from the picture.

The eye-movement data collected in Experiment 2 showed that the unnecessary textual information was processed by students and, more interestingly, that they seemed to start ignoring the unnecessary information with increasing task experience. That is, participants paid less attention to the unnecessary text and made less transitions between the unnecessary and essential information on the later slides, after they had gained some experience with the task. This decrease in attention towards the unnecessary text was accompanied by an increase in attention to the essential text, and more transitions between the essential text and the picture. These results are in line with the findings by Rop et al. (2018), who showed that learners start to ignore pictorial, obviously irrelevant, and separated extraneous information. The present study shows that these results also apply when the extraneous information is textual, unnecessary rather than irrelevant, and when it is integrated or separated with relevant information. This provides further evidence that learners adapt their study strategy and start to focus less on extraneous and more on essential information once they gain experience with a task, which is relevant information for instructional designers.

Although the results also implied that more attention was paid to the essential text on the later slides, this change in study strategy did not lead to improvements in test performance (improvements that were observed by Rop et al., 2018). Surprisingly, the presentation of unnecessary text did not consistently hamper learning about the process of mitosis in the two experiments (i.e., only a small negative effect of separated unnecessary text in Experiment 1, but not in Experiment 2; no negative effect of integrated unnecessary text in both experiments). Because we did not reliably find an initial negative effect of the unnecessary text on learning, the question of whether task experience would reduce or eliminate that negative effect could not be answered. A possible explanation for why the unnecessary information did not initially have a negative effect on learning even though it was processed might lie in the nature of the extraneous information, that is, in whether it is irrelevant or unnecessary. It is possible that the negative effects of irrelevant information on learning would be larger than the effects of unnecessary information. That is, processing irrelevant information not only takes up working memory capacity but also might actively interfere with learning the essential information, by disrupting the processing, organization, and integration of essential information. Processing unnecessary information on the other hand (which is identical in content to the essential information) does take up working memory capacity but may interfere less with learning the essential information.

Another potential explanation might lie in the amount of time that learners had available. We based the time per slide on the average study time of eight participants in a pilot study, which can therefore be assumed to have been sufficient for most of our participants. It is possible that processing unnecessary information would start to hamper learning when there is time pressure. When there is little time available for processing, any time spent on the unnecessary information goes at the expense of thoroughly processing essential information, and as a result, learning is hampered. In the present study, learners may have had sufficient time for processing all sources of information, which would explain why their attention to the unnecessary text (as demonstrated in Experiment 2) did not significantly increase experienced cognitive load and did not negatively affect learning as measured by either the cloze tests or the picture test. Systematically varying the presentation time in future research could shed some light on this issue.

The finding that students adapt their study strategy with increasing task experience is interesting in light of the expertise reversal effect (for a review, see Kalyuga, 2014), which states that learning materials that are essential and nonredundant for novices become redundant when learners gain or have more prior knowledge, at which point they will no longer aid, and might even hinder learning. Although some overlap between the expertise reversal effect and the present study exists, as they both revolve around (parts of) learning materials that become more redundant for certain learners, they are in fact very different. Although an expertise reversal effect would imply that redundant information starts to hamper learning as expertise (with the task content) increases, in our study, it was expected that it would no longer hamper learning as experience with the layout of the task (i.e., task experience) increases.

4.1 | Limitations and future research

It is interesting that we replicated the finding that attention to extraneous information wanes with the present materials, as these are more ecologically valid and more complex than the word learning materials in the studies by Rop and colleagues (2018, 2017). However, a possible limitation of the present study, which might perhaps also explain the lack of effects on learning outcomes, is that the different phases of the process of mitosis are not fully independent of each other. As each phase is building on the information that was provided in the previous phase, the processing of later slides might have been dependent on how well information from the previous slides had been learned. Moreover, some phases might be more complex than others, which is also suggested by the differences in processing time per slide. Another potential limitation is that the cloze test mostly tested retention of the essential text while disruption of relevant learning processes (i.e., selection, organization, or integration; Mayer, 2014) might be more reflected in outcome measures that reflect deeper processing (such as a measure of transfer). Therefore, it is possible that the results regarding learning outcomes would be different when the test would assess understanding (e.g., by means of inference questions). Future studies should try to rule out this possibility by including measures of both retention and transfer. Moreover, because students were tested in between, we should be cautious in concluding that students learned to ignore unnecessary information spontaneously; they may have been aided by the cloze tests, which gave clues regarding the essential information. Again, future studies should test this hypothesis.

Concluding, the results of this study are interesting in that they provide evidence that learners adapt their study strategy and start to ignore unnecessary information with increasing task experience. However, this does not seem to lead to a change in learning outcomes, presumably because we found no initial negative effect of such unnecessary information on learning. Therefore, our results call for further research aiming to pinpoint conditions under which extraneous information presentation negatively affects learning, and employing eye-tracking methodology to study the attention allocation processes during learning may help accomplish this (see also Van Gog & Scheiter, 2010). Next to the nature of the information (irrelevant vs. unnecessary), the format of the information (textual vs. pictorial), and the layout of the information (integrated vs. separated), the role of time on task and the complexity of the learning and test materials should be investigated.

ORCID

Gertjan Rop http://orcid.org/0000-0001-6204-1607

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