Cognitive and affective effects of seductive details in multimedia learning

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ARTICLE INFO

Article history:
Available online 10 December 2014

Keywords:
Multimedia learning
Seductive details

ABSTRACT

The present study integrates cognitive and affective aspects of media processing in order to make an argument for reexamining the current cold cognition perspective in multimedia research in favor of a more integrative perspective. The Cognitive-Affective Theory of Learning with Media (CATLM) assumes that students need to become motivated to make full use of their cognitive resources. Therefore, and even though seductive details (sds) are additional interesting but unnecessary pieces of information that do not conform with the coherence principle, their possible motivational role should not be dismissed. Using a 2 x 3-experimental design, participants (N = 123) were asked to learn about biology with multimedia instruction that manipulated modality (text vs. narration) and presence of seductive details (no-sds vs. textual-sds vs. narrated-sds). Results of variance analyses show a modality effect. In addition, moderated mediation analyses with the moderator modality and mediator situational interest confirm the affective mediation assumption with the following two conditional effects. A direct detrimental effect of seductive details on learning performance under the text-condition and an indirect compensatory effect under the narration-condition were shown.

1. Introduction

In research on multimedia learning, the role of affective processes has not been the focus as much as has been cognitive processing and associated principles. Especially the multimedia principle has become prominent. Studies (Mayer, 2005) have shown that learners learn better with textual and pictorial representations instead of only textual information. Moreover, it is recommended by the coherence principle that only coherent information be presented and that additional unnecessary information, such as seductive details be excluded (Mayer, 2005). In contrast, the Cognitive-Affective Theory of Learning with Media (CATLM; Moreno, 2005, 2006; Park, Plass, & Brünken, 2014) suggests that affect and motivational factors mediate learning by increasing or decreasing the amount of cognitive resources that students invest in the learning task at hand. Students need to become motivated to learn or (in lieu of motivation) use their self-regulation to allocate sufficient cognitive resources to the task at hand (Moreno, 2006). Therefore, and even though seductive details do not conform with the coherence principle, their possible motivational role should not be dismissed in multimedia learning (Park, Moreno, Seufert, & Brünken, 2011).

Seductive details are instructional materials that meet at least the following two necessary conditions: (1) the materials are interesting and (2) the materials provide additional information that is not necessary to accomplish the learning objectives of a lesson (Lehman, Schraw, McCrudden, & Hartley, 2007). Seductive details therefore impose an extraneous cognitive load during learning by forcing students to spend their limited resources in processing materials that distract from or disrupt the construction of a coherent mental model in the learning process. In a study by Park et al. (2011) it was shown that inconsistent results in seductive details research, sometimes confirming the detrimental effect and sometimes presenting non-significant results, can be explained by an effect on cognitive load. The findings showed that students’ learning performance was significantly higher when seductive details were presented under the low load condition (narration) as compared to all other conditions. This finding was interpreted as a motivational effect in the frame of the CATLM. However in this study, no aspects that reflect the assumed affective processes were measured. Thus, the present study looks at the impact of seductive details on learning performance through moderated mediation...
with the moderator modality (high load text vs. low load narration condition) and the mediators situational interest and positive emotions. This research question on how seductive details influence learning performance will be addressed using a regression-based approach to test this affective mediation assumption.

2. Theoretical framework

The present work uses the Cognitive Load Theory (CLT) and the CATLM as a theoretical framework to explain inconsistent results in seductive details research. Both theories are now described in order to present two different perspectives on multimedia learning.

2.1. Multimedia learning processes from a cold cognition perspective

CLT (Plass, Moreno, & Brünken, 2010; Sweller, Ayres, & Kalyuga, 2011) assumes that knowledge acquisition depends on the efficiency of the use of available (limited) cognitive resources. In addition, the extent of cognitive load is determined by three components. First, intrinsic cognitive load characterizes the part of cognitive load caused by complexity of the given task. This load type depends on the extent or number of interacting concepts (element-interactivity) that must be simultaneously processed in working memory to learn the material that is being taught. The greater the number of elements and/or the higher the interactivity of the material that needs to be learned, the greater is the intrinsic cognitive load. Second, extraneous cognitive load is caused by the unnecessary cognitive demands imposed by instructional design. The more optimal the learning material is presented, considering the cognitive architecture and empirically proved instructional design principles, the lower the extraneous cognitive load. Finally, germane cognitive load is the load that results from engaging in learning activities that foster schema acquisition. Whereas extraneous sources of load hinder learning, intrinsic sources of load reflect the complexity of the given learning task in relation to the learner's level of expertise, and germane sources of load promote learning by helping students engage in the process of schema formation and automation. A basic assumption of CLT is that the total cognitive load experienced during learning is additively composed of these three load types, the so-called additivity hypothesis (Moreno & Park, 2010; Park, 2010). If total cognitive load is excessive, learning and problem solving will be inhibited. The triarchic model of CLT is shown in Fig. 1 that is adapted from a summary on the historical development of CLT by Moreno and Park (2010).

Two characteristics of learning materials that are typically associated with extraneous load are the modality of the learning material and the presence of seductive details. Both characteristics can be varied by teachers as well as instructional designers and are often found in educational learning materials at schools or universities. How does the variation of these learning material characteristics influence learning?

2.1.1. Modality – A source of extraneous cognitive load

According to CLT, when visual representations (e.g., pictures, diagrams, animations) are combined with simultaneous text, they force students to split their visual attention during learning. Therefore a detrimental effect on learning performance is apparent. While the empirical base of the learning benefits caused by replacing text with narration (the modality effect), seems to be quite robust (e.g. Ginns, 2005), the theoretical explanation of this effect is still under discussion (Rummer, Schweppe, Fürstenberg, Seuffert, & Brünken, 2010; Schnotz, 2011). The most recent theoretical explanation of the effect is based on auditory recency: When a picture is accompanied by narration, the most recent narrated elements (or even the whole narration, if it is only one sentence) can be represented with some durability in the sensory register. The representation enhances the maintenance of the corresponding verbal information in working memory. This is very helpful, even in case the narration is no longer presented and the learner still looks at the picture. However, when a picture is accompanied by visual text, the visual fixation of the picture immediately overwrites the verbal information in the sensory register (Rummer et al., 2010). In terms of CLT, this explanation shows that learners have more information available for an immediate integration within the learning process. Therefore, using narration instead of text creates a low load learning condition. In contrast, visual-only material causes a high load learning condition because of the multiple visual fixations that are needed for the integration of constantly overwritten visual information in the sensory register. Consequently, this process of re-loading against overwriting creates an extraneous source of cognitive load.

2.1.2. Seductive details – Another source of extraneous cognitive load

How do seductive details influence the learning process? The term “seductive details” was first introduced by Garner, Gillingham, and White (1989) to refer to the addition of interesting but unnecessary information to text which reduces the recall or learning of “non-seductive”, relevant text ideas. Until now, research on the effect of seductive details has focused on seductive text passages or seductive illustrations in text comprehension studies. Several studies have shown a detrimental effect of seductive details (e.g. Garner et al., 1989; Harp & Mayer, 1998; Lehman et al., 2007), whereas others have shown non-significant results (e.g. Garner & Gillingham, 1991). All of these studies showing a detrimental effect used scientific texts that explained concepts such as detailed differences between insects or the lightning process step by step. In contrast, the studies that did not show the detrimental effect of seductive details were using non-scientific texts (e.g. biographies). These results may suggest that seductive details can only interfere with learning within a high load learning process that requires managing the available cognitive resources.

To date, three different explanations for the seductive details effect have been discussed and supported: (1) diversion, (2) disruption of the learning process, and (3) distraction from the relevant learning process (Harp & Mayer, 1998). First, the diversion hypothesis suggests that the seductive details effect is due to the activation of inappropriate prior knowledge functioning as an
organization schema. One activated schema could guide the perspective of the learner into a certain direction for the whole learning session. Therefore, the seductive details effect is based on focused processing of preferred, comprehensible and inherently sense-making information. This was confirmed for text-only material or multimedia learning material (Harp & Mayer, 1998; Rowland, Skinner, Davis-Richards, Saudargas, & Robinson, 2008). Second, Lehman et al. (2007) provide evidence for the disruption hypothesis; that seductive details reduce the amount of time readers spend reading base text sentences, and are harmful for recall processes and deeper processing. The authors argue that these negative effects of seductive details are due to attention allocation and disruption of text coherence. Third, in support of the third explanation, the distracting effect of seductive details, Sanchez and Wiley (2006) argue based on the Controlled-Attention Hypothesis that the extent of controlled attention, limited by working memory capacity, should moderate the seductive details effect. Learners with low working memory capacity were significantly more distracted by seductive details (illustrations), than were those with a higher working memory capacity, and their attention was drawn to seductive details more often and for longer time intervals, as registered by eye tracking (Sanchez & Wiley, 2006).

Consequently, seductive details impose an extraneous cognitive load during learning by forcing students to spend their limited resources in processing materials that divert, disrupt or distract from the construction of a coherent mental model in the learning process. However, in learning situations that are associated with low working memory activity, seductive details do not have a detrimental effect. In contrast, they can even lead to higher performance because of their motivating function for which the required cognitive resources are available (Park et al., 2011).

In sum, from a cold cognition perspective both introduced characteristics, namely the modality of the learning material as well as the presence of seductive details are associated with extraneous cognitive load and should be reduced as far as possible. However, from an integrative perspective, seductive details may play a decisive role to foster learning by increasing learners’ situational interest and thereby improving information processing. This integrative perspective is summarized in CATLM, which we will describe and discuss next.

### 2.2. Toward an integrative perspective on multimedia learning processes

CATLM (Moreno, 2005, 2006) focuses on cognitive and affective processes in multimedia learning. The theory is based on recent theoretical frameworks of multimedia learning and enhances the “cold cognition perspective” by taking motivational and affective aspects into account. The model includes four cognitive assumptions: (1) independent information processing channels, (2) limited working memory capacity as well as a virtually unlimited capacity of long-term memory, (3) dual coding, and (4) active processing. These well-known assumptions are enriched by three new assumptions: (5) the affective mediation assumption – the idea that motivational factors mediate learning by increasing or decreasing cognitive engagement, (6) the metacognitive mediation assumption – the idea that metacognitive factors mediate learning by regulating cognitive and affective processes, and (7) the individual differences assumption – the idea that differences in learners’ prior knowledge (e.g. Kalyuga, Ayres, Chandler, & Sweller, 2003) and traits such as cognitive styles and abilities like spatial ability (e.g. Münzer, Seufert, & Brünken, 2009), for example, affect the efficiency of learning with methods and media. The resulting CATLM model is presented in Fig. 2.

In its last developed version by Roxana Moreno, CATLM only presents a first idea on an integrative perspective. In sum, from this integrative perspective qualitatively different processes can be expected that are characterized by facilitation or inhibition. This perspective on affective processing as a facilitating or inhibiting process during learning is also derived from literature on how affect influences cognitive processing. Both controversial assumptions and a summary of the related studies are presented separately in the following section, with a focus on the two affective factors; positive emotions and situational interest.

#### 2.2.1. Affective processing – A facilitating process during learning

Research on affective processes in learning shows that affect can play a crucial role in cognitive processing. For instance, as summarized by Um, Plass, Hayward, and Homer (2012), numerous studies lend support to the idea that positive emotions have an effect on information, communication and negotiation processing, decision-making, category sorting tasks and creative problem-solving.

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**Fig. 2.** Cognitive-affective theory of learning with media, adapted from Moreno (2006), see also Park, Plass and Brünken (2014), reprinted with permission from Elsevier.
processes. Moreover, a positive emotional state improves recall and can serve as an effective retrieval cue for long-term memory (e.g., Isen, Daubman, & Nowicki, 1987). Finally, the study by Um et al. (2012) shows that including emotional aspects in the design of learning material can induce positive emotions, and that positive emotions facilitate cognitive processing and learning with multimedia instruction. Moreover, research on situational interest (e.g., Flowerday & Schraw, 2003) reveals that situational interest fosters deeper learning measured by memory of main ideas, global understanding of text, and favorable personal reactions to a text (e.g., Schraw, 2000). Situational interest is typically measured during or after the task because the level of situational interest is dependent on the specific characteristics of the task. Schraw, Bruning, and Svoboda (1995) looked at post-learning situational interest that can be measured immediately after learning. Investigating learners’ choice and interest, Flowerday, Schraw, and Stevens (2004) showed that readers’ situational interest, rather than choice or topic interest, promotes reader engagement. Thus, situational interest is associated with “focused attention and the affective reaction that is triggered in the moment by environmental stimuli” (Hidi & Renninger, 2006, p.29), and can be a potential affective mediator in learning processes. In sum, many studies on positive emotions and situational interest assume and confirm that affective processing facilitates cognitive processing.

2.2.2. Affective processing – An inhibiting process during learning

From another point of view, the relative benefit of additional affective processing during learning, geared toward increasing the learners’ interest and motivation, is not great enough to compensate for the added processing demands (Um et al., 2012). Therefore, additional affective processing due to the affective nature of the learning material should not lead to higher learning performance. Using this reasoning, affective processing is seen as an inhibiting factor during learning. Summarized by Um et al. (2012), several studies confirm that emotions suppress cognitive processes. For instance, emotions negatively impact cognition in convergent or analytic tasks, such as deductive reasoning, because the additional demands in working memory lead to interruptions of the cognitive task at hand; moreover, emotions impede encoding and retrieval of information, when experimentally induced. All of these arguments are associated with the resource-allocation theory (Norman & Bobrow, 1975) and represent a largely cognitive perspective on learning. In sum, it is assumed that affective processing generates task-irrelevant thinking that interferes with information processing because it requires cognitive capacity that would normally be allocated to the process of encoding (Pekrun, 1992). These ideas are in line with the cold cognition perspective, presented above.

Finally, the conflicting perspectives on affective processing as a facilitator or inhibitor of learning are in line with research on affect in social thinking and behavior. Recent explanations on how affect impacts information processing suggest that different moods induce qualitatively different styles of processing (Bless & Fiedler, 2006; Forgas, Goldenberg, & Unkelbach, 2009). Negative moods call for accommodative processing, focused on concrete, external information. In contrast, positive moods promote assimilative processing where individuals rely more on abstract knowledge structures and heuristics (Bless & Fiedler, 2006). Following these assumptions, positive moods or affect should facilitate learning with multimedia instruction and encourage construction of an abstract coherent mental model of the learning content. On the other hand, positive moods or affect will not facilitate correct deductive reasoning and analytic thinking, which can also be necessary to reach the goal of a complex learning task. This is the case, when analytic thinking about step-by-step procedures of spatial information is required, as is often the case in complex learning with multimedia instruction. Therefore, both assumptions that affective processing is a facilitating or an inhibiting process are relevant for multimedia learning and depend on the given task and the corresponding style of processing needed.

2.3. Goal of the present study – Research questions and hypotheses

How do seductive details impact learning? The current study investigates whether the seductive details effect is moderated by cognitive load, which should be demonstrated by a modality effect (extraneous cognitive load factor) and an interaction effect. The second research question is in line with the affective mediation assumption of CATLM: Do seductive details play a decisive role in fostering learning by increasing learners’ situational interest and/or positive emotions and thereby inducing an advantageous information processing? To this end, a group of university students (N = 123) were asked to learn about the structure and function of a cellular molecule responsible for the synthesis of adenosine triphosphate (ATP) with the help of an instructional program. The modality of verbal explanation (text vs. narration) of the goal-relevant multimedia learning instruction was varied. In order to adapt the format of seductive details to the modality variation of the multimedia learning instruction, the variation of additional seductive details material (animation + text) was accomplished by presenting the textual part of seductive details (sds) in text format (textual-sds) or narration format (narrated-sds). In sum, the present study uses a 2 × 3 experimental design varying modality of the goal-relevant multimedia learning instruction (text vs. narration) and seductive details (no-sds vs. textual-sds vs. narrated-sds). Learning performance served as dependent variable and students’ subjective ratings of situational interest and positive emotions served as mediators in a moderated mediation analyses.

Hypotheses (1–8). (1) A modality effect is expected, which is indicated by a significantly higher learning performance and a significantly lower subjectively rated extraneous cognitive load when learning with narration. (2) An interaction effect is expected showing the detrimental effect of seductive details under the high load text condition and a motivational effect of seductive details under the low load narration condition. And, (3) the best performance is expected in the narration-narrated-sds condition in contrast to all other conditions due to the motivating role of seductive details under a low load narration learning condition. Under this condition, situational interest and/or positive emotions can be developed due to available resources and affect learning performance in a facilitating way. Thus, (4) the highest ratings of situational interest and positive emotions are expected in the narration-narrated-sds condition in contrast to all other conditions, too. (5) The lowest learning performance is expected in the text-narrated-sds conditions, where (6) situational interest and/or positive emotions are not growing due to the high load text situation. In this situation, seductive details divert, disrupt or distract from learning processes leading to an inhibiting process that is not fostering positive emotions or situational interest. This finally leads to the detrimental seductive details effect on learning performance. With a regression-based approach the moderated mediation analysis helps to answer the questions about whether or not the seductive details effect is mediated by situational interest and/or positive emotions, and if so, in what way. One hypothesis (7) is that mediation only becomes apparent under low load narration condition but not under high load text condition as situational interest and/or positive emotions can only develop in optimal learning situations (low load narration/motivating). However, in suboptimal learning situations (high load text/non-motivating) situational interest does not develop. This hypothesis can be tested by model A (see Fig. 3). A contrasting hypothesis (8) is that situational interest and/or positive emotions develop in both learning situations (narration or text), but this has a different impact on learning per-
formance in optimal vs. suboptimal learning situations (narration vs. text). This hypothesis has to be tested by model B, see Fig. 3.

3. Method and data sources

3.1. Participants and design

The participants were 123 university students (66.7% female, average age = 22.11 years, SD = 3.67), all majoring psychology. Three participants had to be excluded from data analysis because of technical problems with data recording. Modality of the goal-relevant multimedia learning instruction (text vs. narration) and seductive details (no-sds vs. textual-sds vs. narrated-sds) were varied in a 2 × 3 factorial design, leading to six learning conditions: text-no-sds; text-textual-sds; text-narrated-sds; narration-no-sds; narration-textual-sds; narration-narrated-sds. Participants were randomly assigned to one of the conditions and received test-person hours that are necessary to get credit points for their bachelor.

3.2. Materials

The multimedia instruction used in this study pertained to the structure and function of a cellular molecule responsible for the synthesis of ATP. It included 11 screens, each one with static pictures and corresponding verbal explanations (440 words all pages together). The objective of the learning task was to understand the complex structure of and the step-by-step processes within the molecule by integrating the verbal representations (see Fig. 4, below left on each screen) with the corresponding pictorial representations (see Fig. 4, top left on each screen). This learning objective was explicitly stated during the introductory portion of the program that was common to all treatment conditions. In contrast, knowledge about the usefulness of ATP was not part of the objectives of the learning task. This is the reason why we chose to show concrete information of the usefulness of ATP in different domains (e.g., sports, work, etc.) to the participants in the seductive detail conditions.

Based on the seductive details literature, seductive details were defined and operationalized in order to achieve high construct validity by using the following six criteria: The additional information was rated as (1) significantly more interesting (Garner et al., 1989) than the rest of the learning material, which was confirmed by ratings of university students within a pilot study, t(10) = 6.59, p < .001, confirming previous ratings of high school students (Park et al., 2011); (2) not necessary to achieve the learning objectives of the lesson (Garner et al., 1989); (3) representative of a discrete category of information that in general could be easily recalled because of its high level of interest and its concreteness (e.g. Sanchez & Wiley, 2006); (4) brief in nature (2–3 information units per screen or only on 4 of 11 screens; 147 words), not exceeding 30% of the number of information units in the control condition (Goetz & Sadoski, 1995); (5) tangentially related to the key content (Garner, Brown, Sanders, & Menke, 1992); and (6) seductive in the sense of “emotional” material that is associated for example with our body, feelings, love or death (Garner et al., 1992), e.g. in our case, feeling the power and pleasure of sports and work, the seduction of partners by lightning bugs, or the death. In CLT terms, the seductive details can be categorized as intelligible in isolation, but not necessary to reach the learning-goal and therefore an extraneous cognitive load source for learning the objectives of the lesson (e.g. Chandler & Sweller, 1991).

A manipulation check was realized by asking the students to answer different retention tasks concerning the seductive details material. As the seductive details material is very easy to understand this test does not represent learning performance. However, the retention tests shows how much learners did remember from this nice-to-know-but-irrelevant information confirming that learners really perceived this information. The retention test included eight open format questions like for example “Write down three examples where ATP is used in the world of animals”. Learners received a maximum of 10 points if they remembered all the information correctly.
The other varied factor of modality was operationalized by replacing the visual explanations with identical narrated explanations in the form of a male voice. For all seductive-detail conditions, seductive details were presented in a multimedia format of additional text and animated pictures (see Fig. 4, top and below right on each screen). In both conditions with narrated seductive details, the seductive details text part was presented by narration in the form of a male voice (see Fig. 4, top right on screen 9/11).

Time-on-task was controlled because learners were not able to go backwards. They did have to be on the screens for at least the minimum time (empirically tested minimum reading time of the screens) and could only be on the screen for a given maximum time (approximately 2 min). In addition, time-on-task was automatically recorded by the computer to be able to control for statistical significant between-group differences.

### 3.3 Measures

Four control measures were used: (1) prior knowledge, measured with a questionnaire, Cronbach’s $\alpha = 0.80$, that included five multiple-choice and eight open-ended questions (e.g., “Do you know the term ‘ATP’? If yes, then please write down its meaning! (catchwords)”; (2) spatial ability, measured by a standardized paper-folding and card-rotation test (Elstrohm, French, & Harmann, 1976), as spatial ability was found to play a facilitating role in learning with multimedia instruction by Münzer et al. (2009) using the same learning material as in the present study.

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**Fig. 4.** Screenshots of the learning environment used in all conditions showing the on-screen text (text or narration; lower left corners), corresponding pictures (top left corners), and seductive details (additional text or narration and animated pictures on the right sides on four of 11 screens); original version in German, translated by the authors.
(3) time-on-task; and (4) participants learning motivation, measured by a revised short version of the 100-item Inventory of School Motivation (ISM; Mc荫ney & Sinclair, 1991) that was previously used in research by Flowerday (2005) with a Cronbach’s \( \alpha \) of .87. This revised version was translated into German as well as adapted for university students by the first author. For instance, the following items were presented: “I like to see that I am improving in my performance” and “Doing well in university will help me reach my goals.”, in sum showing a Cronbach’s \( \alpha \) of .86 in the present study.

Learning performance was assessed with a learning performance test including 11 items that are associated with problem solving tasks (e.g., “What happens with the sub elements Alpha and Beta during the rotation of the axis?”/open response format), transfer tasks (e.g., “Which cells do feature the highest number of mitochondrions?”) and if their open responses accorded with the matching task). Learners received a maximum of 11 points if they answered all the matching tasks well (one point per correctly matched item) and if their open responses accorded with the example responses. The solution probability of each item lies between \( p = .20 \) and \( p = .80 \) and a high interrater-reliability between 4 independent raters was found, \( ICC(3,1) = .96, p < .001 \). The reliability of the learning performance test shows a Cronbach’s \( \alpha \) of .67. These items were not identical to the 13-item prior knowledge test described above, which was only used to control prior knowledge.

Extraneous cognitive load was measured by a subscale, which included three items originally and was reduced by one item due to a higher internal consistency with Cronbach’s \( \alpha \) of .59 instead of .54. This subscale had been constructed to differentiate between the three types intrinsic, extraneous and germane load, already introduced by Koch, Seufert, and Brünken (2008) and Park (2010). The present subscale shows at least construct validity as the following items that are associated with the unnecessary cognitive demands imposed by instructional design: “How easy or difficult did you find it to (1) . . . differentiate between relevant and irrelevant information? (2) . . . collect all information you needed?” asking for ratings on a seven-point Likert scale for both items. These items are explicitly not associated with complexity of the task per se (intrinsic load) or learning-conducive effort of learners (germane load).

Situational interest was measured by 10 items that were adapted in a study by Flowerday and Schraw (2003) and Flowerday et al. (2004) from the perceived interest questionnaire used by Schraw et al. (1995), who showed that all items load on a single factor with a coefficient alpha of .86. Learners have to rate on a five-point Likert scale how strongly they agree or disagree with a series of statements (1 = strongly disagree, 5 = strongly agree). Typical items were, “I thought the issue was fascinating” and “I got caught-up in the issue without trying to”. Total scores could range from 1 to 5. In the present study, this situational interest scale was translated into German by the first author and all items were also loading on a single factor, explaining 62.91% of the overall variance. A high internal consistency was found with a Cronbach’s \( \alpha \) of .93.

Positive emotions were measured by the positive affect subscale of the PANAS-X General Dimension Scale (Watson & Clark, 1994), which asks to indicate to what extent the person feels active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, and strong. The German version reported with Cronbach’s \( \alpha \) of .86 by Grünth, Kotter-Grünth, and Rücke (2010) was used.

In the present study, a factor analysis shows that the positive emotion items were not loading on the same factor as the situational interest items were loading. This indicates that both indicators refer to different constructs, although they correlate with each other, \( r = .64, p < .01 \). This is why we used both affective indicators as two separate dependent variables in the following analysis within a MANOVA procedure.

### 3.4. Procedure

The study was conducted in one session (about 75 min). Students were tested for learning motivation, spatial ability, and prior knowledge, before the multimedia learning program started. Then, students completed the situational interest inventory, the scale for positive emotions, and finally the differentiating cognitive load scale and the learning performance test. The students of the seductive details conditions also needed to answer the retention test on seductive details information.

### Table 1

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<th>Text-narrated-sds</th>
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<th>Narration-textual-sds</th>
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<td>(0.23)</td>
<td>(0.34)</td>
<td>(0.26)</td>
<td>(0.47)</td>
<td>(0.50)</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Seductive details retention performance</td>
<td>5.93</td>
<td>6.03</td>
<td>5.94</td>
<td>5.68</td>
<td>5.70</td>
<td>5.94</td>
</tr>
<tr>
<td>Max</td>
<td>(0.87)</td>
<td>(1.09)</td>
<td>(0.97)</td>
<td>(1.40)</td>
<td>(1.49)</td>
<td>(0.94)</td>
</tr>
</tbody>
</table>

Note: Means on first line; Standard Deviations in brackets; Max = maximum score.
4. Results

Table 1 shows the means and standard deviations of all variables for the six treatment conditions. When conducting $2 \times 3$ ANOVAs, no statistical significant between-group differences were detected in any of the four control variables prior knowledge, spatial ability, time-on-task, and learning motivation, all $F$s < 1 or $p$s > .05. With respect to its high inter-individual variance and the mentioned evidence of the facilitating role (Münzer et al., 2009), we used spatial ability as a covariate in the following analyses of covariance. The prerequisite for an ANCOVA that there are no interactions between spatial ability and the independent variables for all dependent variables in question was given. The results of the corresponding ANOVAs all showed non-significant interactions, $F$s < 1. In addition, learners of the seductive details conditions showed that they perceived the seductive details information with a retention performance of $M = 5.84$ (SD = 1.15; min. = 3 and max. = 8; theoretical maximum of 10) that is 58.4% of the possible retention (see Table 1). The four seductive details conditions did not show any difference in their retention performance, $F < 1$.

4.1. Learning performance and extraneous cognitive load

We conducted separate ANCOVAs using experimental condition as the between-subject factor and the learning performance score and extraneous cognitive load ratings, respectively, as dependent variables. In this way, we were able to test Hypotheses 1, 2, 3 and 5. The first ANCOVA showed a main effect of modality, $F(1,118) = 3.14$, $p < .05$, $\eta^2_p = .03$, and no main effect of seductive details, $F < 1$, as well as no interaction effect, $F < 1$, in learning performance. Contrast tests showed that learners reached the highest learning performance under the narration-narrated-sds and the narration-no-sds condition (no difference between both conditions: $\Delta M = .07$, n.s.) in contrast to all other conditions (i.e., in contrast to narration-textual-sds: $\Delta M = .39$, n.s.; text-no-sds: $\Delta M = .46$, n.s.; text-textual-sds: $\Delta M = 1.07$, $p < .10$; text-narrated-sds: $\Delta M = 1.46$, $p < .05$; see Fig. 5). Further contrast tests indicate that the performance of the learners of the text-narrated-sds condition is lower in contrast to all other conditions (i.e., in contrast to text-textual-sds: $\Delta M = -.39$, n.s.; text-no-sds: $\Delta M = -1.0$, $p < .10$; narration-no-sds: $\Delta M = -1.53$, $p < .05$; narration-textual-sds: $\Delta M = -1.0$, $p < .10$; narration-narrated-sds: $\Delta M = -1.46$, $p < .05$; see Fig. 5). In sum, Hypothesis 1 is confirmed, Hypothesis 2 not, and Hypothesis 5 can be only partly confirmed as the results underpin the expected detrimental seductive details effect under the high load text conditions showing on the descriptive level an increase in performance without seductive details. Thus, a marginally significant detrimental effect was shown under the text condition for narrated seductive details (text-no-sds vs. text-narrated-sds: $\Delta M = -1.00$, $p = .10$), but not for textual seductive details (text-no-sds vs. text-textual-sds: $\Delta M = -.61$, n.s.). Moreover, under the low load narration condition, learners demonstrated significantly better performances shown by the modality effect. In addition, the best performance under the narration condition was shown with or without narrated seductive details, which does not indicate a motivational effect (Hypothesis 3), but a compensatory effect.

The second ANCOVA showed a main effect of modality, $F(1,118) = 3.24$, $p < .05$, $\eta^2_p = .03$, but no main effect for seductive details, $F < 1$, as well as no interaction effect, $F(2,118) = 1.5$, $p < .05$, in extraneous cognitive load. This indicates that the positive learning effect of the narration versions was accompanied by lower levels of self-reported extraneous cognitive load. In addition, learners did subjectively not estimate to be cognitively loaded, which means distracted or disrupted very much by the seductive details. These ratings are contrasting the objectively measured low learning performance, shown by the contrasts above (see Fig. 6).

4.2. Situational interest and positive emotions

The MANCOVA results using situational interest and positive emotions ratings as dependent variables to test the expected effects of affective processes during learning (Hypothesis 4 and 6) show no main effect of modality $F(1,118) = 1.54$, $p > .05$, and no main effect of seductive details as well as no interaction effect, $F < 1$, in situational interest. In addition, no main effect of modality, $F(1,118) = 1.10$, $p < .05$, of seductive details and no interaction effect, $F < 1$, were shown in positive emotions. Contrast tests showed that learners rated their situational interest and positive emotions under the narration-narrated-sds condition to be higher (Hypothesis 4) in contrast to all other conditions (i.e., situational interest: in contrast to narration-textual-sds: $\Delta M = .27$, n.s.; narration-no-sds: $\Delta M = .27$, n.s.; text-no-sds: $\Delta M = .46$, $p < .05$; text-textual-sds: $\Delta M = .31$, n.s.; text-narrated-sds: $\Delta M = .29$, n.s.; positive emotions: in contrast to narration-textual-sds: $\Delta M = .14$, n.s.; narration-no-sds: $\Delta M = .16$, n.s.; text-no-sds: $\Delta M = .36$, $p < .05$; text-textual-sds: $\Delta M = .18$, n.s.; text-narrated-sds: $\Delta M = .21$, n.s.). The highest situational interest of learners accompanied by the most intensely experienced positive emotions was found under the
narration-narrated-sds condition (Hypothesis 4). The lowest situational interest accompanied by the less intensely experienced positive emotions was found under the text-no-sds condition; in all other conditions ratings were found on a medium level (partly conform with Hypothesis 6; see Figs. 7 and 8).

This indicates that learners of the narration-narrated-sds condition with the best learning performance confirm to have developed the highest situational interest and experienced the most intensely positive emotions. In contrast, under the high load text condition without seductive details, a performance on a medium level is accompanied by the lowest rated situational interest and positive emotions. Therefore, Hypothesis 4 and 6 could be partly confirmed.

4.3. Moderated mediation analyses

To assess the extent to which situational interest and positive emotions might be mediating the relationship between seductive details and the learning outcome in a differential way depending on the moderator modality, we conducted a moderated mediation analysis. This analysis uses a regression-based approach that is the conditional process modelling procedure outlined by Preacher and Hayes (2008) and Hayes and Preacher (2013).

Preacher and Hayes (2008) recommend the investigation of multiple mediation and analyzing the specific indirect effects, which are caused by individual mediators transmitting the effect. All of these analyses should be done by the bootstrapping procedure when using infinite samples. In addition, the authors mention that multiple mediators are more likely to explain a mediation than only a single mediator. In the present study, one more step was needed to consider the additional expected moderation by modality (cognitive load) of the expected affective mediation effect. All in all, the present study needed to revert to a model that allowed a moderated multiple mediation analysis with the moderator modality and the mediators situational interest and positive emotions. The conditional process modelling procedure corresponding to the conceptual model A or B was used (see Fig. 3). Moreover, for a reasonable interpretation of indirect effects, it is necessary to use the comparison of two experimental conditions. Thus, the following results only include the completely varied modality conditions in a 2 $\times$ 2 factorial design with the factor seductive details (no-sds vs. narrated-sds) and the moderator modality (narration vs. text). Moreover, the analyses included all other selected variables of the study as covariates in order to statistically account for shared associations between variables in the causal system caused by other sources.

The analysis by Model A showed a significant model summary for the learning outcome, $F(5, 74) = 2.38$, $p < .05$, $R^2 = .15$, and resulted in a marginally significant effect of seductive details, $\beta = .16$, $t(79) = 1.25$, $p = .10$, and a marginally significant effect of modality, $\beta = .28$, $t(79) = 1.34$, $p < .10$ on learning performance. No effect of the interaction term seductive details x modality was found, $\beta = -.09$, $t(79) = -1.08$, n.s. In addition, a marginally significant conditional direct effect of seductive details on the learning outcome in the text condition, effect = .07, $t(39) = 1.26$, $p = .10$, and no conditional effect in the narration condition, effect = -.02, $t(39) = -.28$, n.s. was found. Using 5000 bootstrap resamples, the conditional indirect effect of seductive details on the learning performance by the mediator situational interest was not found in the text condition, given that the 95% confidence interval includes zero, BootLLCI = -.0605 and BootULCI = .0302, and therefore the indirect effect does not differ significantly from zero. However, the indirect effect was found in the narration condition, BootLLCI = -.0002 and BootULCI = .1017. We can therefore conclude that situational interest mediates the effect of seductive details only under the low load narration condition, but not under the high load condition on learning performance, on the path from seductive details to the mediator $(X \rightarrow M;$ Hypothesis 7). For the mediator positive emotions no conditional indirect effects were found (text condition: BootLLCI = -.0212/BootULCI = .0562; narration condition: BootLLCI = -.0904/BootULCI = .0127).

The following results were found with the analysis by Model B. The analysis also showed a significant model summary for the learning outcome, $F(12, 67) = 2.03$, $p < .05$, $R^2 = .28$, and resulted in a marginally significant effect of seductive details, $\beta = .21$, $t(79) = 1.61$, $p < .10$, and no effect of modality, $\beta = .34$, $t(79) = 1.03$, n.s. on learning performance. No effect of the interaction term seductive details x modality was found, $\beta = -.10$, $t(79) = -1.11$, n.s. In addition, also a significant detrimental conditional direct effect of seductive details on the learning outcome turned out in the text condition, effect = -.12, $t(39) = 2.02$, $p < .05$, and no conditional effect in the narration condition, effect = .02, $t(39) = .39$, n.s. However, by using bootstrapping, the conditional indirect effect of seductive details on the learning performance by the mediator situational interest was not found in any of the two conditions of the moderator (text condition:...
BootLLCI = −0.0063/BootULCI = 0.0727, narration condition: BootLLCI = −0.0340/BootULCI = 0.0556). For the mediator positive emotions the same result was found: no conditional indirect effects (text condition: BootLLCI = −0.0813/BootULCI = 0.0065; narration condition: BootLLCI = −0.0512/BootULCI = 0.0129). We can therefore conclude that in this model no mediation is apparent. In sum, Model B showed the detrimental conditional direct effect of seductive details on learning performance in the text condition again. However, this model did not confirm the moderated mediation on the path from the mediator situational interest to the learning performance (M → Y; Hypothesis 8).

5. Conclusions and discussion

Theories and empirical studies that integrate cognitive and affective processes in multimedia learning (Moreno, 2005, 2006; Um et al., 2012) assume and confirm that affective factors mediate learning. In spite of this, affective processing in research on multimedia learning has received less than adequate attention. The present paper shows how situational interest mediates the seductive details effect under different modality/cognitive load conditions. The results confirm the affective mediation assumption in the way that situational interest mediates learning under a low load narration condition leading to a compensatory effect. Seductive details are not detrimental under this condition, as compared to the shown direct (no mediation) detrimental effect of seductive details under the high load text condition. These findings have several interesting theoretical and practical implications.

5.1. Theoretical and practical implications

The present results lead to theoretical implications for three research areas.

First, for modality research, this study’s results for modality effect shows once again that learners learn better with narration in contrast to text accompanying complex pictorial information. In addition, learners’ higher level of learning performance can be maintained if the narration includes additional interesting, but unnecessary narrated information. This indicates that the modality effect is resistant to narrated seductive details. Learners are able to compensate the distraction, disruption or diversion effect of seductive details normally found under visual-only conditions. This compensatory effect confirms the strength of the auditory recency-effect (Rummer et al., 2010).

Second, seductive details research profits from the present study that again shows differential effects of seductive details on different cognitive load learning situations, as already found by Park et al. (2011). Even though no motivational effect was found, a compensatory effect under the low loading narration condition indicates that seductive details can be processed. This is the case, if learners have enough cognitive resources free for integrating this interesting, but unnecessary learning material. Moreover, especially the format of narrated seductive details seems to have differential influence on the learning processes. Textual seductive details can be ignored. Therefore it could be that in some experimental studies only using textual/visual seductive details learners did not read/perceive the additional interesting, but unnecessary information. In contrast, with the present study, it was shown that especially the narrated seductive details interfere with learning. They disrupt the “re-loading-against-overwriting” processes that are needed in learning with visual-only material described by the auditory-recency explanation for the modality effect. Even though the learners have enough time to learn before and after the disrupting information is presented, the detrimental effect of narrated seductive details is apparent under a high load text condition. As the automatically starting narration inherently attracts the attention and disrupts the already started learning process, the disruption and distraction hypotheses could be confirmed within the present experimental design of the study. In contrast, when this disrupting auditory information is integrated in an auditory loop of learning-goal relevant information, seductive details do not interfere with learning. This indicates a modality-specific effect of seductive details that leads also to concrete practical implications for teachers and instructional designers that will be discussed later in this section.

Third, for research on multimedia learning and recent integrative perspectives focussing on cognitive and affective learning processes, the affective mediation assumption (Moreno, 2005, 2006) could be confirmed for situational interest, but not for positive emotions. Situational interest mediated the compensatory effect under the low load narration condition. Moreover, it was shown by using conditional process modelling procedure that situational interest can only develop under the low load narration situation (model A) and does not grow per se due to interesting material (model B). On the one hand, this can be seen as a confirmation for the resource-allocation framework that affective processing can only emerge in case of free cognitive resources, which are not allocated to the task at hand. This argument was underlined by significantly lower extraneous cognitive load ratings under the narration condition. On the other hand, it could imply that modality itself has a positive effect on affective processing. This could also be explained by narration that is more emotional due to the human voice in contrast to dry textual information. However, we did not find any significant effect of modality on positive emotions or situational interest, which contradicts this hypothesis.

A final question arises that is relevant for research on multimedia learning: What does this higher level of situational interest add to the learning situation when finding a pure compensatory effect? Hidi and Renninger (2006) summarize that situational interest is associated with focused attention and the affective reaction that is triggered in the moment by environmental stimuli, in our case the seductive details. Thus, in the present study seductive details lead to focused attention and affective reaction that was leading to a high quality learning process. This process suggests that the development of situational interest within the learning process influences future learning behavior in a positive way, which can be seen by ratings on items of the situational interest scale asking for future learning behavior. Thus situational interest not only facilitates present learning processes, but is also assumed to facilitate future learning behavior. This is one point that needs further investigations, as it is relevant for practical instructional decision-making; to add or not to add seductive details.

Finally, research on how affect (situational interest, positive and negative moods or emotions) impacts information processing can profit from the present contrasting results. In the present study, learners had to think about the mechanical step-by-step procedures of a system that includes moving elements and much spatial information. This has to be processed by correct deductive reasoning and analytic thinking, and therefore not only assimilative but also accommodative processing was necessary. Thus, situational interest was shown to also mediate accommodative processing styles that are not assumed to be mediated by positive emotions or moods (Bless & Fiedler, 2006). This implies that the affective processing due to situational interest is appropriate to learning situations where accommodative processing is needed.

Practical applications for our results are first, that seductive details should only be added under low load learning situations. Instructional designers, teachers and learners need to consider not only the working memory capacity of the learner, but also the estimated extraneous cognitive load the to-be-learned material
will bring into the learning situation. Second, the format of combining pictorial information with narration still is one of the most optimal methods for instruction, as used by teachers at schools and lecturers at universities. And finally, the results of the present study suggest that situational interest is beneficial for learning-conducive processing. Furthermore, situational interest can be increased through the use of an optimal instructional design, such as a mixed modality-seductive details design. For example, if presenting a slide-show that is accompanied by a rhetorical well prepared talk or a highly user-friendly webcast as are often used in modern self-regulated online-learning situations today, this mixed-modality material can provide seductive details information, as defined in the materials part (see 3.2). They are used in order to motivate the learner and will not interfere with the goal-relevant learning process. However, if learning material only consists of textual and pictorial information, seductive details should be avoided. In sum, the relevant question, which has to be considered by instructional designers and teachers for effective and efficient learning is, do learners have enough cognitive resources free for using motivating bits and pieces of information? If they do, seductive details might be innocuous or even beneficial to learning outcomes and can foster further learning behavior by inducing situational interest.

5.2. Limitations and future directions

It should be mentioned that there are also some important limitations to the present study. First, as is the case for all empirical studies, the generalizability of our findings is limited. Further research needs to investigate whether our findings can be applied to other populations, subject matter areas, and types of learning materials. Second, further research needs to investigate whether the present findings can be found for different levels of learning performance like retention as well as transfer or application performance. This would be especially interesting to investigate because it will be possible to test the explanations of Bless and Fiedler (2006) that different moods induce qualitatively different styles of processing. Within these investigations, the learners should not only receive an explicit hint to the learning goal of the learning session, but should over that be asked to write down their learning goal to be able to check this manipulation. Until now, seductive details studies did not check their manipulation by asking the learners again to expatiate their learning goal. Third, further research should include process measures like eye tracking to be able to analyze how learners in detail do interact with learning material. This could also be used as an additional manipulation check to determine whether and how learners actually looked at the seductive details. In addition, eye movement data could also be used to measure cognitive load in an objective, reliable and valid way instead of the current used scale. This would recognize the recent discussion on how to measure cognitive load with subjective and objective measures in a valid and reliable way, which is still open and has to be mentioned here (Plax et al., 2010). The present subscale was one attempt to overcome the methodological problems by using a subscale that shows at least construct validity. And the results should be considered carefully due to the rather low internal consistency. However, the use of eye movement data for analyzing the modality effect would not be the best choice of instrument for measuring differences in cognitive load, as the narration version will not produce eye-tracking data that are useful to interpret the auditory processing. This is why other objective and modality-unspecific measures should be used like for example the rhythm method (Park, 2010; Park & Brünken, in press) that is based on the dual-task paradigm and is therefore more complex for an implementation in comparison to the use of subjective rating scales.

Finally, the present research was initiated as a way of moving from the current cold cognition perspective in multimedia research to a more integrative perspective. Further research is needed to empirically test other specific affective mediation assumptions. As Bless and Fiedler (2006) assume that negative moods facilitate the accommodative processing styles, further research should also investigate the ways that negative affect influences learning processes of different styles in multimedia learning. To this end, we encourage researchers to explore new methods of analysis that utilize a regression-based approach to test further affective mediation assumptions. These methodologies allow researchers to test mediations, moderated mediations, or mediated moderations and will be very fruitful for further multimedia studies that investigate cognitive and affective processes within an integrative experimental framework.

Acknowledgements

This research was supported by the German Federal Ministry of Education and Research (01PL12057). The authors wish to thank Tobias Gall, who was very engaged to realize the present study by programming the learning material. We also thank the editor Paul A. Kirschner and all anonymous reviewers for their very helpful comments.

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