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Do Learner Characteristics Moderate the Seductive-Details-Effect? A Cognitive-Load-Study Using Eye-Tracking

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ABSTRACT

The present study examines whether the seductive-details effect is moderated by spatial ability and prior knowledge, which are two of the most relevant learner characteristics in multimedia learning. It is assumed that the seductive-details effect with an increase in extraneous cognitive load and a decrease in perceptual processing and learning success is only present for learners with low spatial ability and low prior knowledge. To this end, the present study uses an Aptitude-Treatment-Interaction Design with separate analyses for spatial ability and prior knowledge as aptitude-variables and seductive details (with vs. without) as treatment-variable. Participants ($N = 50$) were asked to learn about biology with a multimedia instruction that manipulated seductive details. The results show that learners perceptual processing, measured by eye-tracking, and learning performance was significantly lower when learning with seductive details. In addition, spatial ability and especially prior knowledge were confirmed to play the expected moderating role.

Keywords

Seductive details, Multimedia learning, Spatial ability, Prior knowledge, Eye-tracking

Introduction

The design of computer-based multimedia learning instructions has many options concerning the integration of additional, non-redundant and interesting but irrelevant learning material in form of pictures, text, animated sequences, videos or audio commentaries. These options are more than playing with colors and/or shapes of the relevant learning material as recommended by emotional design principles that can evoke learning-conducive affective processing in multimedia learning (Park, Knörzer, Plass, & Brünken, 2015; Park, Plass, & Brünken, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014). The additional, non-redundant and interesting but irrelevant information is also used to make the learning material more interesting and attractive to learners (Park, Flowerday, & Brünken, 2015). However, in fact such additional information can also decrease the learning performance.

Until now, research on this negative 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 (Garner, Gillingham, & White, 1989; Harp & Mayer, 1998; Lehman, Schraw, McCrudden, & Hartley, 2007; McCrudden & Corkill, 2010), whereas others have shown non-significant results (Garner & Gillingham, 1991; Hidi & Baird, 1988). All of these studies showing a detrimental effect were using scientific texts that explain for example detailed differences between insects or the lightning process step by step. In contrast, the studies that could not show the detrimental effect of seductive details were using non-scientific text. This already is a hint to the idea that seductive details can only interfere with learning within a high-loading learning process that requires managing the available cognitive resources.

In a study by Park, Moreno, Seufert and Brünken (2011), it was shown that controversial results in seductive-details research 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. Concerning particular learner characteristics a similar effect should appear: If the degree of cognitive load is responsible for the strength of the seductive-details effect and the individual degree of cognitive load is affected by learner characteristics, there should be learner characteristics that moderate the seductive-details effect. To this end, the goal of the present study was to test this hypothesis for two learner characteristics that are supposed to affect the individual cognitive load while learning with multimedia learning instructions: prior knowledge and spatial ability.

Theoretical framework and predictions

According to the Cognitive Load Theory (CLT) (Plass, Moreno, & Brünken, 2010; Sweller, Ayres, & Kalyuga, 2011) the total cognitive capacity is limited and the amount of total cognitive load is determined by three components. First, intrinsic cognitive load depends on the element interactivity. The larger the number of elements that must be processed in working memory and the more complex their relation to each other is, the higher the intrinsic load. Second, extraneous cognitive load is directly caused by the format and concept of the information presentation. A proper instructional design fosters information processing and saves cognitive resources by minimizing extraneous cognitive load. Third, germane cognitive load is the load dedicated to relevant information processing. The higher the engagement in learning and schema acquisition is, the higher the germane load. Seductive details consist of additional interesting but irrelevant information, are part of the instructional design and can therefore be allocated to the extraneous load factor. So adding seductive details to a learning content causes additional extraneous load and may overstrain the learners' cognitive capacity. Within an extraneously low loading instructional design (e.g., audio-visual learning material), participants may have enough capacity to process the relevant learning content and the seductive details whereas in an extraneously high loading instructional design (visual-only learning material) the processing of additional information decreases learning performance (Park et al., 2011). However, there is still the question about how exactly seductive details affect information processing and learning within an extraneously high loading learning instruction as often found in learning environments of schools and universities (e.g., text books, handbooks, hypertexts including pictorial information).

Theoretical explanations for the seductive-details effect

Harp and Mayer (1998) provide three explanations for the seductive-details effect, the diversion, disruption or distraction of the relevant learning process. First, the diversion hypothesis assumes that seductive details activate inappropriate prior knowledge and cause inappropriate schemata that are organized by integrating the new information with the activated prior knowledge. Some studies tested the effect of schema interference by manipulating the presentation order of seductive details in the way that seductive details were presented at the beginning, interspersed, or at the end of the learning material (Harp & Mayer, 1998). As seductive details did only affect learning in a negative way, when presented before or within the learning session and not when presented after the learning session, the results support the diversion hypothesis and the assumption of schema interference. In case of the presentation of seductive details before or early in the learning session, students try to integrate this information or use the seductive-details information like an anchor for the whole learning session leading to the wrong focus of information perception and processing during the learning session. Second, the disruption hypothesis assumes a coherence disruption of the relevant information processing by seductive details. A study by Lehman et al. (2007) gives support for this assumption showing that seductive details reduce reading time of relevant sentences in scientific text and decrease the recall of main ideas. Third, the distraction hypothesis assumes an attention distraction of the relevant information processing by seductive details. Sanchez and Wiley (2006) investigated the influence of working memory capacity, as a learner characteristic, on the effect of seductive illustrations and animations. Learners with low working memory capacity were significantly more disturbed by seductive details (illustrations), than those with a higher memory capacity and drew their attention more often and for longer time intervals to seductive details, as registered by eye-tracking. In sum, cognitive capacity seems to be of great importance to explain the seductive-details effect and so should learner characteristics be very important for the explanation of the seductive-details effect because they influence the use of cognitive resources during the learning process, too.

Prior knowledge and spatial ability

A very important learner characteristic assumed to affect the effect of instructional multimedia design principles on learning success is the learners' prior knowledge (Kalyuga, Chandler & Sweller, 1998). Research on the expertise reversal effect shows that the application of several supportive instructional design principles do only increase the learning success for learners with low prior knowledge, whereas learning success for learners with high prior knowledge is unaffected or even decreased (Kalyuga, Ayres, Chandler & Sweller, 2003). Thus, the assumption suggests itself that learners with high prior knowledge are affected in another way than learners with low prior knowledge, when learning with seductive details. According to CLT, element interactivity can be decreased by domain-specific knowledge and the intrinsic cognitive load for learners with high prior knowledge should be lower than for learners with low prior knowledge. As mentioned above, seductive details affect the learning success especially under high load conditions (Park et al., 2011), so the seductive-details effect should affect learners with low prior knowledge in a significantly stronger way than learners with high prior knowledge. A study by Magner, Schwonke, Aleven, Popescu, and Renkl (2014) gives clear support for this assumption.

Another important learner characteristic is the learners' spatial ability. Especially while learning with a multimedia instruction that uses visual-figural and three-dimensional-spatial information, the learners' spatial ability is of great importance for the construction of three-dimensional mental representations out of two-dimensional visual figural information (Münzer, Seufert, & Brünken, 2009). For instance, in a study by Mayer and Sims (1994) it was shown that the contiguity effect is strong for high spatial ability participants, thus only the high spatial ability learners performed better under concurrent presentation of narration and animation. This finding supports the assumption that spatial ability fosters the construction of a mental model and that building such a visual representation is much more demanding for low spatial ability learners. Thus, high spatial ability learners should be less affected by seductive details because handling a three-dimensional mental animation should be less demanding and should cause less intrinsic cognitive load. As the focus of attention is very important in order to construct such three-dimensional mental models when learning with multimedia instruction, we also assume spatial ability to affect learners' focus of attention. Thus, a detrimental effect of seductive details and a moderating influence of prior knowledge and spatial ability is not only expected for the learning performance but also for the focus of attention, indicated by eye-movement data. With respect to the study by Magner et al. (2014), the present study realizes a closer look on the moderating influence on learning success by a detailed analysis of learners' information processing.

Eye-tracking the seductive-details effect

To get a closer look on the influence of seductive details on the learners' information processing, eye-tracking methodology can be a very useful tool. As it's indicated by several studies there is evidence for a close relation between eye-movement measures like total fixation time and cognitive activity that supposes e.g., long fixation time as an indicator for high cognitive activity (Just & Carpenter, 1976). Moreover, the total fixation time on the relevant picture in multimedia learning is hypothesized to cause cognitive processing and to serve as a measure of cognitive performance (Rayner, Li, Williams, Cave & Well, 2007). Eye-tracking provides information about the perceptual processing while learning and in combination with measures of learning success it provides information about cognitive processing (Mayer, 2010). If particular learner characteristics have a moderating influence on the seductive-details effect, these learner characteristics should also affect the learners' eye movement.

As mentioned above, seductive details consist of additional but irrelevant information. Concerning eye-tracking research, Canham and Hegarty (2010), for instance, found an effect on the ability to focus task-relevant information dependent on the participants' domain knowledge, in the way that higher knowledge enhanced information selection. The learners' prior knowledge should not only reduce intrinsic load but also enhance the information selection. Therefore, perceptual and cognitive processing should be affected by the learners' prior knowledge and the learners' prior knowledge should moderate the seductive-details effect, indicated by measures of perceptual processing.

For a better understanding of the seductive-details effect it could be useful to analyze when the learners look at relevant information for the first time. An appropriate eye-tracking measure for assessing the learners starting point of the information processing is the time to first fixation. This measure of perceptual processing provides information about the order of the learners' fixations and about the time the learners start processing particular relevant information (Hyönä, 2010). One possible detrimental effect of seductive details is the learners' attention distraction of cognitive processing the relevant information (Garner et al., 1989). If the presentation format of relevant and seductive-details material is hold constant, the learners' first fixations provide information about the influence of seductive details on their primary attention focus during the first seconds of the learning process.

In addition, eye-tracking data about the fixations on relevant pictorial information are assumed to provide information about the cognitive activity caused by the construction and handling of a visual mental representation. A process close to the handling of mental models and also related to spatial ability is the integration of verbal and figural information. Especially the transitions between semantically related text and pictorial information are assumed to indicate the cognitive engagement during the integration process of verbal and figural information (Holsanova, Holmberg & Holmqvist, 2009; Schmidt-Weigand, Kohnert & Glowalla, 2010). Thereafter, the influence of the learners' spatial ability on cognitive processing while learning with multimedia instruction should be indicated by several measures of perceptual processing in the form of a moderating effect, when analyzing seductive-details material.

Goal of the present study

The present study examines whether the seductive-details effect is moderated by memory associated learner characteristics such as spatial ability and by expertise related factors such as prior knowledge. It is assumed that processing seductive details will result in a decrease of the learning success. Furthermore it is assumed that learning with seductive details also affects the learners' cognitive load. The learners who are working with the seductive-details version should experience significantly higher cognitive load in comparison to those working with the no-seductive-details version. If the seductive-details effect is moderated by spatial ability and prior knowledge, it is assumed that the seductive-details effect with an increase in cognitive load and a decrease in learning success is only present for learners with low spatial ability and low prior knowledge.

The present study further examines whether seductive details affect perceptual processing and whether this seductive-details effect is moderated by the learners' prior knowledge and spatial ability. The seductive-details effect should be based on a decrease of the total fixation time and the total number of fixations on the relevant pictures, as well as the transitions between relevant textual and pictorial information. Furthermore it is assumed that seductive details also affect the learners' first attention focus during perceptual processing. The learners who are working with the seductive-details version should fixate the relevant information later than those working with the no-seductive-details version. If the seductive-details effect is moderated by prior knowledge and spatial ability, it is assumed that the seductive-details effect with a decrease in factors of perceptual processing is only present for learners with low prior knowledge and low spatial ability.

Method and data sources

Participants and design

In order to assess the seductive-details effect on perceptual processing and learning success and the moderating role of learner characteristics an aptitude-treatment-interaction design was used, spatial ability and prior knowledge served as aptitude-variables and seductive details (with vs. without) as treatment-variable. The moderating effects of spatial ability and prior knowledge were assessed in separate analyses, as there was no significant correlation found between both aptitude-variables ($r = .263$, *ns*). Participants were 50 psychology students from a German University (79.6% female, average age = 22.1 years, $SD = 3.0$). They were randomly assigned to one of the two experimental groups.

Materials

Both groups worked with a self-directed multimedia-learning program that consists of 11 screens presenting an instruction about the structure and function of the ATP Synthase, a cellular molecule responsible for synthesis of ATP. The relevant information was presented as a combination of static pictures (see Figure 1, top left on each screen) and corresponding textual explanations (see Figure 1, below left on each screen). The objective of the learning task was to achieve a deep understanding of the molecule structure and the single steps in the process of ATP synthesis by integrating the verbal and pictorial representations (text = 440 words all pages together). All participants were introduced to the learning objective at the beginning of the learning task.

The experimental group worked with the seductive-details version, presenting additional and highly interesting but irrelevant information on 4 of the 11 screens in form of illustrations and related text on the right side of the screen (see Figure 1). In contrast to the relevant information, seductive details provided information about the usefulness of ATP that was not part of the learning objective. According to former studies seductive details were chosen by the following aspects: interestingness, irrelevance, concreteness, conciseness, emotionality and reference to the relevant topic (Garner et al., 1989; Park et al., 2011; Park, Flowerday, & Brünken, 2015; Sanchez & Wiley, 2006).

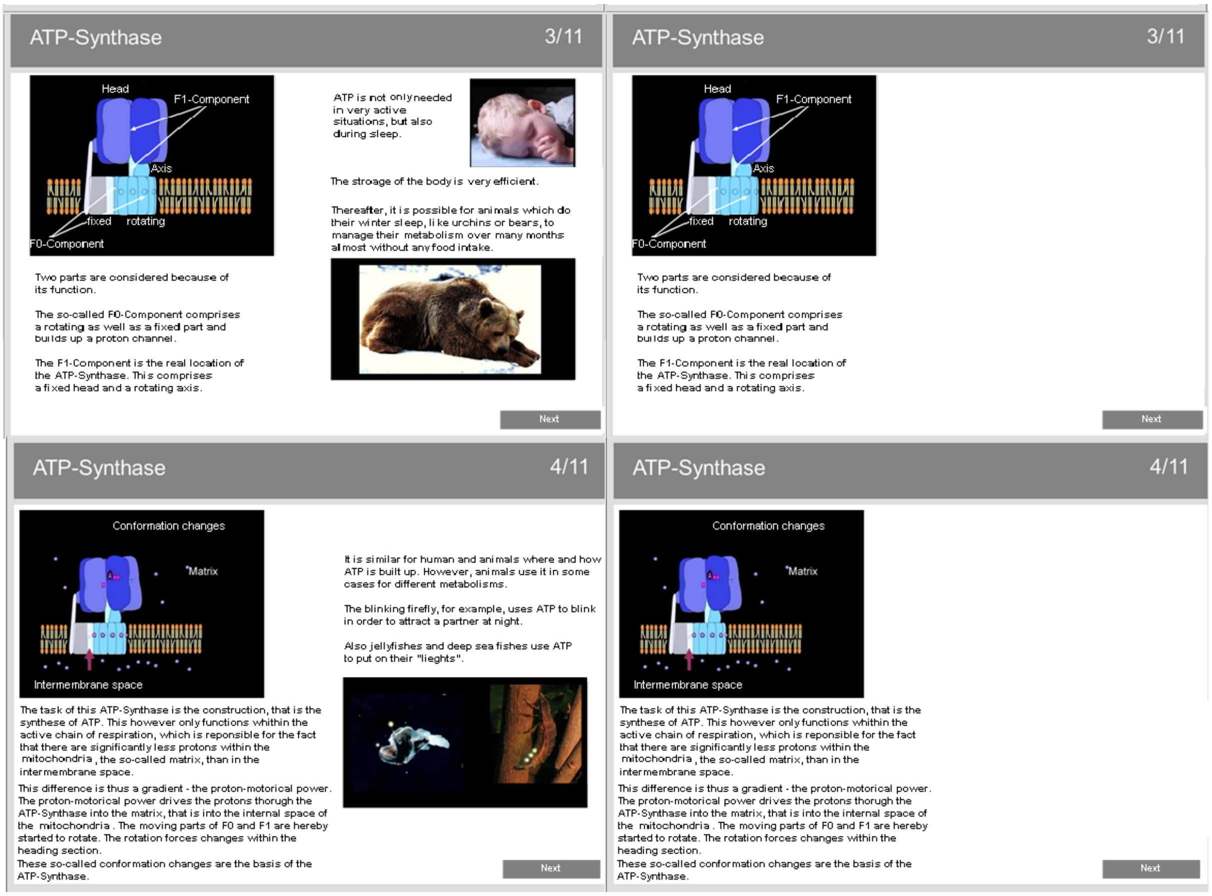

Figure 1. Example screens of the learning environment for the experimental group (seductive-details version, see left example screens) and the control group (without seductive details, see right example screens); original version in German, translated by the authors.

Measures

Working memory capacity measured by the numerical-memory-updating subtest of Oberauer, Süß, Schulze, Wilhelm, and Wittmann (2000), time-on-task, registered automatically by the computer, and participants learning motivation, measured by a revised short version of the 100-item Inventory of School Motivation (ISM; McInerney & Sinclair, 1991) Cronbachs' α = 0.86, served as control measures.

Prior knowledge was measured by a questionnaire that included five multiple-choice and eight open-ended questions, Cronbachs' α = 0.86. Spatial ability was measured by a standardized paper-folding and card-rotation test (Ekstrom, French, Harman, & Dermen, 1976).

Learning success was assessed by a learning-performance test including 12 items. The difficulty of each item lies between p = .20 and .80. The differentiation between two levels of required cognitive processing was considered by using the two subscales retention and comprehension. The subscale retention included 5 items, 3 in multiple-choice format and 2 in open response, showing a Cronbachs' α of 0.71. The subscale comprehension included 7 items, 3 in multiple-choice format and 4 in open response, showing a Cronbachs' α = 0.85.

The participants' eye movements were recorded with a remote eye-tracking system (Tobii-TX300). Areas of interest (AOI) were defined only for relevant text and relevant pictures on each screen of the learning instruction (see Figure 1, relevant text and pictures on the left side of the screens) and not for the seductive-details material on the right side of some of the screens. The analyses focused on the total fixation time on the relevant picture, the total number of fixations on the relevant picture, the time to the first fixation on the text and picture AOIs, and the learners' transitions from text to picture AOIs.

In addition, total cognitive load was measured by subjective ratings (Paas, 1992). Participants were asked to rate their cognitive load in the middle of the lesson (after screen 4 of 11) and immediately after the lesson on a seven-point Likert-scale. The mean of both ratings was used as subjective ratings of cognitive load in the following analyses.

Procedure

Participants started with the working memory capacity test, followed by the tests of spatial ability and prior knowledge. The experimental group worked with the seductive-details version and the control group with the no-seductive-details version of the multimedia instruction. Eye movements were recorded while learning. Subjective ratings on cognitive load were collected once after learning screen four and once at the end of the learning instruction. Finally, participants completed the learning performance test.

Results and conclusions

The two groups did not differ significantly concerning prior knowledge, $F(1,48) = 1.07$, *ns*, spatial ability, working memory capacity, time-on-task, or learning motivation, $Fs < 1$, (see Table 1). In addition, the first screen of the learning program shows only text, that is the same for all participants and was used to control the eye-movement variables. There were no significant differences between the groups concerning the number of fixations or total fixation duration, $Fs < 1$. In addition, independent samples *t*-tests were conducted for learning success, eye movement and cognitive load with the between subject factor seductive details (with vs. without).

Table 1. Means and standard deviations for all control variables

	No seductive details (*n* = 25) *M*(*SD*)	Seductive details (*n* = 25) *M*(*SD*)
Prior knowledge (max. = 13)	3.64(3.19)	4.62(3.5)
Spatial ability (%)	75.80(12.84)	72.80(17.94)
Working memory capacity (max. = 6)	3.88(1.4)	3.92(1.1)
Time-on-task (min.)	7.15(3.53)	7.47(3.25)
Motivation (max. = 5)	3.67(.25)	3.6(.33)
Number of fixations for slide number 1 (*N*)	187.04(97.2)	162.17(109.3)
Total fixation duration for slide number 1 (sec.)	56.8(36.04)	50.01(37.84)

The first *t*-test shows that comprehension performance was significantly lower in the seductive-details group, $t(48) = 2.45$, $p = .009$, $d = .71$. No significant difference was found for retention performance, $t(48) = .278$, *ns* (see Table 2). This result confirms the seductive-details effect on a higher level of required cognitive processing measured by the comprehension-subscale.

When analyzing the eye-movement behavior of the experimental group in contrast to the control group on the slides where seductive details appear for the experimental group, different effects were found. First of all, learners showed significantly shorter total fixation times on the relevant pictorial information in the seductive-details group in contrast to learners who learned without seductive details, $t(43) = 1.806$, $p = .039$, $d = .55$. Second, learners of the seductive-details group executed significantly fewer fixations on the relevant pictorial information, $t(43) = 2.234$, $p = .015$, $d = .68$. Third, the seductive-details group fixated the relevant pictorial information significantly later than the group without seductive details, $t(42) = -2.412$, $p = .010$, $d = .74$. Finally, learners of the seductive-details group demonstrated significantly fewer transitions between the relevant textual and pictorial information in contrast to learners who learned without seductive details, $t(43) = 3.253$, $p = .001$, $d = .99$ (see Table 2).

Moreover, learners of the seductive-details group rated their cognitive load to be significantly lower in contrast to learners of the no-seductive-details group, $t(48) = 1.83$, $p = .036$, $d = .53$ (see Table 2).

Table 2. Means and standard deviations for all variables

	No seductive details (n = 25) *M*(*SD*)	Seductive details (n = 25) *M*(*SD*)
Comprehension (max. = 16.5)	10.6(3.0)	7.9(4.7)
Retention (max. = 12)	7.54(2.2)	7.32(3.3)
Cognitive load (max. = 7)	5.1(.93)	4.4(1.6)
Total fixation duration on the relevant pictures = Picture AOIs (sec.)	50.9(33.9)	34.8(25.3)
Total fixation count on the relevant pictures = Picture AOIs (*N*)	204.8(158.25)	121.6(81.3)
Transitions from relevant text to relevant picture = Transitions between text and picture AOIs (*N*)	23.7(16.3)	11.9(7.7)
Time to first fixation (sec.)	0.26(0.31)	2.06(3.49)

In order to investigate the moderating role of spatial ability or prior knowledge, respectively, on the seductive-details effect, separate moderation analyses were conducted. Spatial ability or prior knowledge served as moderator and learning success, eye-movement data or subjective ratings of cognitive load were used as dependent variables. The conducted moderation analysis is a regression-based approach for conditional process modeling by Hayes (2013).

The first analysis assesses the moderating influence of spatial ability on the seductive-details effect concerning learning success. A moderation analysis was conducted for comprehension with spatial ability as moderator. The regression model was significant, $F(3,45) = 2.8$, $R^2 = .16$, $p = .050$. In accordance with the result of the *t*-tests, the regression analysis shows a main effect for seductive details, $t(45) = -2.08$, $\beta = -1.11$, $p = .043$, but no main effect for spatial ability $t(45) = 1.37$, $\beta = 5.09$, *ns* and no interaction effect, $t(45) = .72$, $\beta = 2.65$, *ns*. The regression coefficients show (marginal) significant conditional effects for the 10th, 25th, and 50th (but not for the 75th and 90th) percentiles of spatial ability, with $\beta = -1.66$, $p = .084$; $\beta = -1.41$, $p = .045$; and $\beta = -1.12$, $p = .043$, indicating that learners with low levels of spatial ability are more affected by seductive details (see Figure 2).

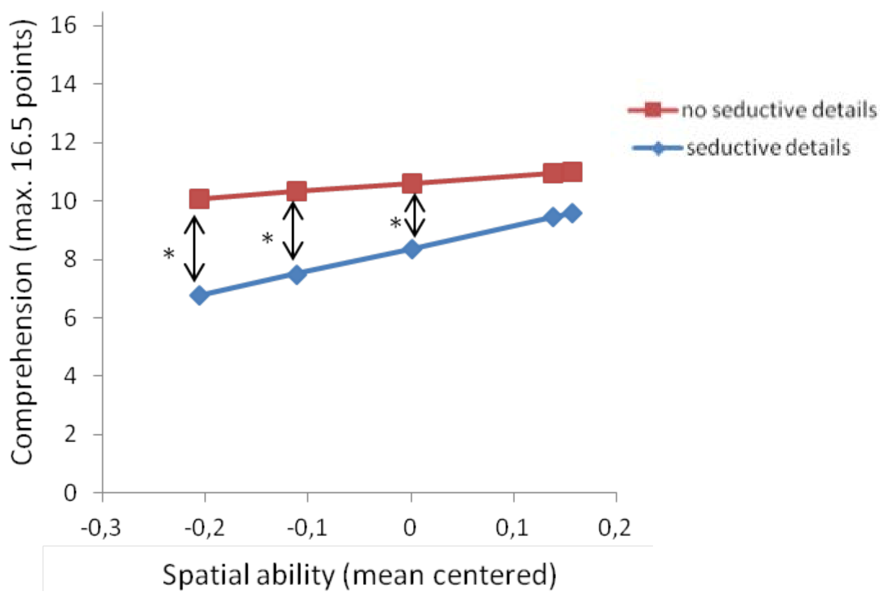

Figure 2. Comprehension moderated by spatial ability

In purpose of assessing the moderating influence of prior knowledge on the seductive-details effect concerning learning success, a moderation analysis was conducted for comprehension. The regression model was significant, $F(3,46) = 3.8$, $R^2 = .20$, $p = .016$. In accordance with the result of the *t*-test, the regression analysis shows a main effect for seductive details, $t(46) = -2.8$, $\beta = -1.53$, $p = .007$. There was also a main effect for prior knowledge $t(46) = 2.08$, $\beta = .34$, $p = .042$, but no interaction effect, $t(46) = .66$, $\beta = .11$, *ns*. The regression coefficients show (marginal) significant conditional effects for the 10th, 25th, 50th, and 75th (but not for the 90th) percentiles of prior knowledge, with β = -1.98, *p* = .027; β = -1.87, *p* = .016; β = -1.65, *p* = .006; β = -1.27, *p* = .065, indicating that learners with low prior knowledge are more affected by seductive details (see Figure 3).

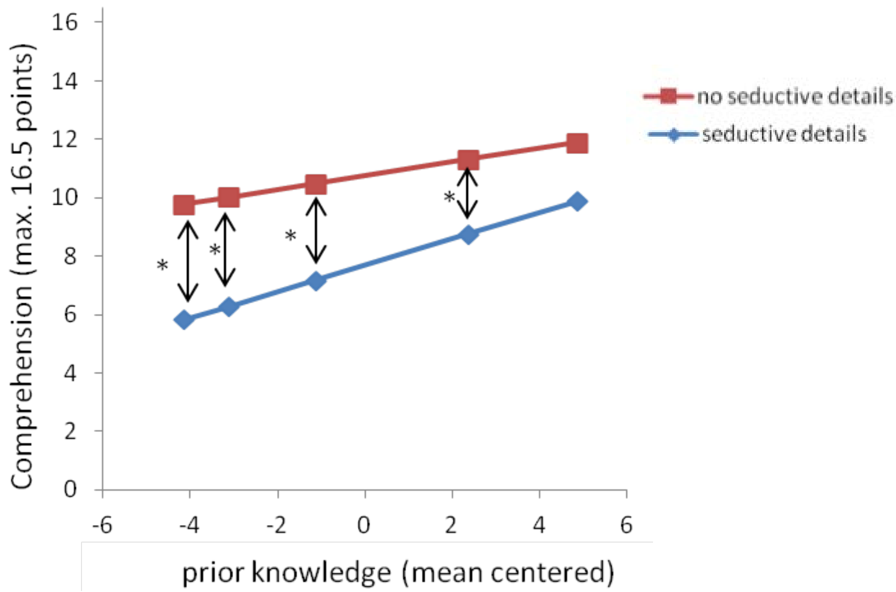

Figure 3. Comprehension moderated by prior knowledge

To assess the moderating influence of spatial ability on the seductive-details effect concerning perceptual processing, an additional moderation analysis was conducted for one measure of eye movement with spatial ability as moderator. Because the transitions between text and picture AOIs are the most relevant indicator for perceptual processing as well as for integration processes and therefore most interesting when analyzing the aptitude-treatment-interaction between spatial ability and seductive details, the following results focus on this indicator.

The regression model was significant, $F(3,40) = 3.2$, $R^2 = .19$, *p* = .034. In accordance with the result of the *t*-test, the regression analysis shows a main effect for seductive details, $t(40) = -3.07$, β = -5.99, *p* = .003, but no main effect for spatial ability $t(40) = -.50$, β = -7.06, *ns*, and no interaction effect $t(40) = .51$, β = 7.36, *ns*. The regression coefficients show (marginal) significant conditional effects for the 10th, 25th, 50th, and 75th (but not for the 90th) percentiles of spatial ability, with β = -7.46, *p* = .042; β = -6.77, *p* = .011; β = -5.94, *p* = .004; β = -4.92, *p* = .081, indicating that learners with low levels of spatial ability are more affected by seductive details (see Figure 4). Learners of the no-seductive-details group show fewer transitions the higher their spatial ability even though they show the same high learning performance. However, when learning with seductive details, this advantage due to high spatial ability seems not to be present: Learners show the same integration activity by using transitions from relevant text to relevant pictures with low or high spatial ability, but their learning performance increases with increasing spatial ability (compare Figure 2 and 4). Thus, seductive details reduce the integration activity and processes and hinder learners with low spatial ability to reach a high learning performance. However, seductive details do not hinder learners with high spatial ability to reach a high learning performance, while showing a comparable low investment of integration processing to learners with low spatial ability.

In order to assess the moderating influence of prior knowledge on the seductive-details effect concerning perceptual processing, a separate moderation analysis was conducted for one measure of eye movement with prior knowledge as moderator. Transitions between text and picture AOIs are again the most relevant indicator for perceptual processing as well as integration processes and therefore also chosen for the following analysis.

The regression model focusing on the transitions between text and picture AOIs was significant, $F(3,41) = 4.7$, $R^2 = .25$, β = -5.62, *p* = .006. In accordance with the result of the *t*-test, the regression analysis shows a main effect for seductive details, $t(41) = -3.01$, β = -5.62, *p* = .004, but no main effect for prior knowledge, $t(41) = -1.66$, β = -.94, *ns*, and no interaction effect, $t(41) = .84$, β = .48, *ns*. The regression coefficients show (marginal) significant conditional effects for the 10th, 25th, 50th, and 75th (but not for the 90th) percentiles of prior knowledge, with β =

7.66, p = .014; β = 7.18, p = .008; β = 6.22, p = .003; and β = 4.55, p = .055 indicating that learners with low levels of prior knowledge are more affected by seductive details (see Figure 5).

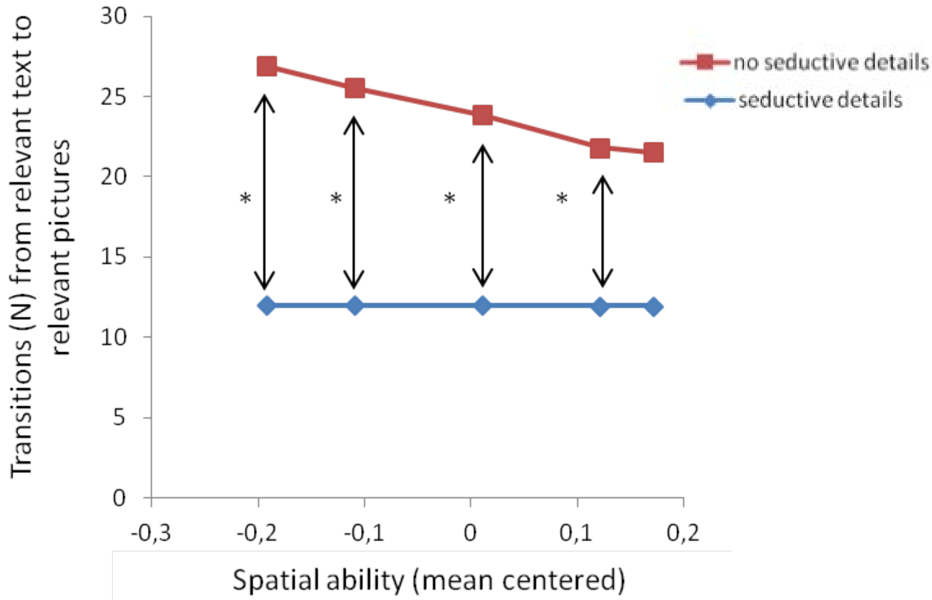

Figure 4. Transitions between text and picture AOIs moderated by spatial ability

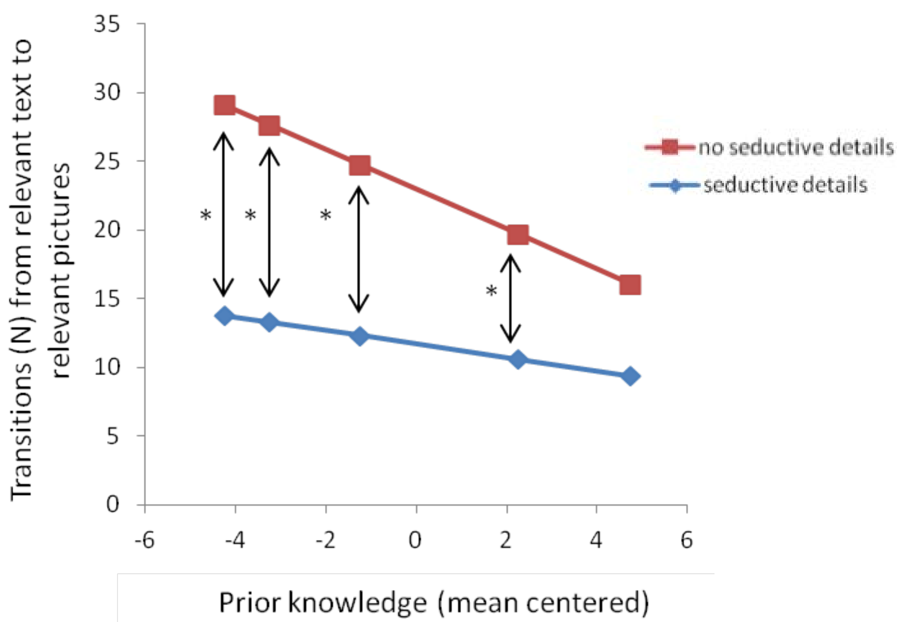

Figure 5. Transitions between text and picture AOIs moderated by prior knowledge

In purpose of assessing the moderating influence of spatial ability or prior knowledge, respectively, on the seductive-details effect concerning cognitive load, two separate moderation analysis were conducted. Spatial ability served as moderator in the first analysis. The regression model was not significant, $F(3,45) = .82, R^2 = .05$, *ns*. Prior knowledge was chosen as moderator in the second analysis. The regression model was significant, $F(3,46) = 5.3$, $R^2 = .26$, $p = .003$. Results show an effect for prior knowledge, $t(46) = -3.28$, $\beta = -.17$, $p = .002$, with higher cognitive load ratings for learners with low prior knowledge, but no effect for seductive details, $t(46) = -1.5$, $\beta = -.26$, *ns*, no interaction effect, $t(46) = -.79$, $\beta = -.04$, *ns*, and no conditional effects of the moderator.

Discussion

Seductive-details effect due to disrupting processes

In sum, the results confirm our hypothesis and show a detrimental effect of seductive details not only on learning success but also on perceptual information processing. The eye-tracking data show that seductive details influence mainly the processing of relevant pictorial information and cause a less deep information processing. The seductive-details group fixated the relevant pictorial information for a shorter time interval, less frequently in contrast to the no-seductive-details group and executed less integrative transitions from text to picture AOIs. These findings are very interesting because time-on-task was not strictly controlled in this study, as learners only had to be on the screens for at least the minimum time (empirically tested minimum reading time of the screens) and could be on the screen for a given maximum time (approximately 2 minutes). Learners in the seductive-details group had the possibility to process the relevant information with the same extent as the group without seductive details. However, seductive details affected their focus of attention and especially their allocation of processing time. Thus, the results give support for the disruption hypothesis (Lehman et al., 2007) with a harmful effect on deeper processing and a reduction of processing time for the relevant information. Further research and a more detailed analysis of the eye-tracking data is needed to assess the disruption hypothesis and to answer the question if seductive details indeed interrupt the processing of the relevant information and disrupt coherence formation. As the integration of textual and pictorial information was crucial for learning success, transitions between relevant and seductive-details information instead of transitions between relevant textual and pictorial information was one possible explanation for such a disruption of the learning process. Recent studies (Jian, Wu, & Su, 2014; Tsai, Hou, Lai, Liu, & Yang, 2012) already used an analysis of individual fixation sequences and comparisons of structural models of gaze direction to assess the eye movements during the construction of mechanical representations in more detail. Dewhurst, Nyström, Jarodzka, Foulsham, Johansson, and Holmqvist (2012) also used different methods based on the “levenshtein distance” to compare series of gazes. Such an approach could be useful to assess the disruption hypothesis for seductive details within a multimedia learning instruction and to have a closer look on the structural or sequential component of information processing.

Seductive-details effect due to distracting processes

As the seductive-details group fixated the picture AOIs significantly later, this behavior can be assumed to be an indicator for a distraction effect. In combination with the moderating effects of prior knowledge these results give support for the distraction hypothesis (Sanchez & Wiley, 2006). Students with high prior knowledge were less affected by seductive details, which indicates with regard to the cognitive-load explanation that high prior knowledge learners experienced lower intrinsic cognitive load and more available capacity to compensate or even profit from seductive details (Park et al., 2011). Nevertheless, prior knowledge does not only reduce intrinsic cognitive load, it can also enhance the information selection. As an expertise related factor prior knowledge can enhance the ability to differentiate between relevant and irrelevant information to focus attention on relevant information processing and to decrease the seductive-details effect (Canham & Hegarty, 2010). Thus, the enhanced information selection could be another way how prior knowledge fosters to compensate for extraneous load effects like the seductive-details effect. In addition, Magner et al. (2014) found an interaction effect for seductive illustrations with prior knowledge and assumed that high prior knowledge learners are affected but only concerning high demanding cognitive activities that overburden their cognitive capacity. The results of the present study give support for this assumption. Within the used multimedia-learning instruction comprehension performance requires high demanding cognitive activity because complex mental models including moving parts have to be built out of pictorial and textual information. The results of the regression models indicate an increase in cognitive load also for high prior knowledge learners in the seductive-details condition, with a decrease in transitions and a decrease in learning success. However, the difference between high prior knowledge learners in the seductive-details group and high prior knowledge learners in the group without seductive details is not significant. Thus, seductive details also affected the high prior knowledge learners, but they were able to compensate in learning performance especially in contrast to the low prior knowledge learners in their own group. The rising question due to these results is now how learners with high prior knowledge compensate. Again further research and a more detailed analysis is needed to assess the question if high prior knowledge in contrast to low prior knowledge learners really tend to ignore seductive details and to investigate less cognitive activity in processing them or if they process the relevant information first and the seductive-details information afterwards.

Further support for the distraction hypothesis (Sanchez & Wiley, 2006) is given by the moderating influence of spatial ability. A study by Meneghetti, Gyselinck, Pazzaglia, and De Beni (2009), for example, shows the impact of spatial ability on mental model construction, processes of text-picture integration and its close link to working memory capacity. Thereafter, it is easier for learners with high spatial ability to construct mental models out of textual and corresponding pictorial information. In addition, high spatial ability learners are able to compensate under cognitively high demanding conditions and maintain their performance in contrast to low spatial ability learners. The present study gives support to these assumptions. The moderating effects for spatial ability show that high spatial ability learners were less affected by seductive details in comprehension even though they show comparable integrative transitions to the low spatial ability learners and less integrative transitions in contrast to the high spatial ability learners in the group without seductive details. Thus, transitions seem to be important especially for learners with low spatial ability and are indeed very important for information integration and mental model construction. As especially the information processing of the relevant pictorial information was affected by seductive details as well as the integrative transitions from textual to pictorial information, the assumption suggests itself that seductive details indeed affect cognitive processes of integration and model construction. In general it can be assumed that high spatial ability learners have more available capacities to process visuospatial information under cognitively high loading learning conditions so that they know to compensate seductive details and other extraneous cognitive-load effects (Seufert, Schütze & Brünken, 2009).

Seductive-details effect due to perfunctory processes

Concerning the measurement of cognitive load during learning activity the results in the subjective ratings (Paas, 1992) indicate lower cognitive load in the seductive-details group. This result contradicts to our hypothesis. A possible explanation for this result is that seductive details in the present study indeed decreased the germane cognitive load by introducing perfunctory information processing of the relevant information; therefore learners probably rated their cognitive activity based on that part of information processing. This assumption is supported by the decrease in total fixation duration and the total number of fixations on the relevant pictorial information, as well as by the decrease of integrative transitions between textual and pictorial information, that indicates less cognitive activity for relevant information processing (Just & Carpenter, 1976; Schmidt-Weigand et al., 2010). This perfunctory processing could also originate from diversion leading to the phenomenon of illusion of knowing (Glenberg, Wilkinson, & Epstein, 1982) in the way that learners seem to activate irrelevant schemata from the seductive-details material (examples of the use of ATP) instead of the relevant learning material (the structure and function of the ATP molecule) and thereafter have the illusion to have learned appropriately enough, however with low subjective-ratings in cognitive load due to their diverted focus of attention on the easy-to-learn material of seductive details. To answer this question further research is needed, especially concerning the interaction of the different cognitive-load factors. Further research should anyway involve objective cognitive-load measures like for example the rhythm method (Park & Brünken, 2015) and fine-grained instruments for subjective ratings to measure the different cognitive-load factors (Leppink, Paas, Van Gog, Van der Vleuten & Van Merrienboer, 2014).

Final conclusion

In sum, learners with low levels of spatial ability and prior knowledge were affected much stronger by seductive details than learners with high levels of both learner characteristics. The results show a decrease in cognitive load, indicated by perfunctory processing of the relevant information and a decrease in learning success. Information processing as well as learning success was moderated by spatial ability and especially by prior knowledge. Thus, the present study gives support for an individual approach concerning the research on learning and instruction with a focus on learner characteristics and shows that eye-movement analysis provides detailed information about the individual information processing that can be especially beneficial for the design of multimedia-learning instruction. The resulting practical implication for instructional designers, teachers and learners is only to use seductive details in case of already established high prior knowledge and/or in case of instructing high spatial ability learners. The most appropriate instructional design would be an adaptive learning-system where prior knowledge and spatial ability are tested before the learning session and learners profit from the individually adapted learning-environment due to the consideration of these different and most relevant learner characteristics in multimedia learning.

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