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Sascha Schneider*, Steve Nebel, Günter Daniel Rey

E-Learning and New Media, Faculty of Humanities, Technische Universität Chemnitz, Germany

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ABSTRACT

Recent studies have shown that the positive emotional design of learning environments might foster learning performance. In contrast, the seductive detail effect postulates that additional, learning irrelevant details inhibit learning. This research focusses on the implementation of decorative pictures as a prime for emotions and context-relatedness. This study examines four groups of decorative pictures which might be conducive for learning. Eighty-two students were randomly assigned to one cell of a 2 (emotionally positive vs. emotionally negative pictures) × 2 (school context vs. leisure context pictures) between-subjects, factorial design. The dimensions of pleasure, arousal, and dominance are examined as possible mediators. Results show that either positively valenced pictures or learning pictures foster retention and transfer performance. Pleasure is identified as mediator of the effect between valence of pictures and learning performance. A further analysis shows differences for arousal and dominance for both factors. These results are interpreted with concepts like motivated attention and other arousal theories.

1. Introduction

Research on multimedia learning has dramatically changed over the last few years as its theoretical focus shifted from “cold” into “hot” cognition. Whereas cold cognition theorists are convinced that learning takes place when enough selective attention and reasoning is available (e.g. Kane et al., 2004), hot cognition approaches claim that other factors like emotional conditions enlarge or diminish working memory capacities and learning results (Klein & Boals, 2001). Following this new approach within the field of multimedia learning, affective support has been shown to promote learning in combination with cognitive support (Huk & Ludwigs, 2009). For this, not only elaborated theories like the Cognitive Load Theory (CLT; Sweller, 1994; 2011), but also several design principles have to be reconsidered, as pictures, videos, animations and other forms of interactive media might evoke different states of emotion (Lindström & Bohlin, 2011). For example, the seductive detail effect (Harp & Mayer, 1998) is concerned with the question how irrelevant but interesting information affects learning outcomes. Seductive detail effect studies show that additional pictures can be helpful as long as they are not irrelevant (Butcher, 2014), however, illustrations used in the most of these experiments are not controlled by their affective impact. This study provides a first insight into the possibilities of affective pictures within the field of multimedia learning. For this, current trends of the implementation of an emotional design are presented and the role of seductive details within this field is highlighted. Moreover, a first differentiation of decorative pictures based on the current literature is created in order underline possible effects of affective influences within decorative pictures.

2. Multimedia and affect

Within multimedia learning arrangements, affect states have not only been shown to influence learning outcomes but also cognitive processes.

The *emotional design hypothesis* postulates that designing features with the goal to impact learners' emotions will influence learning performance (Park, Knörzer, Plass, & Brünken, 2015). If elements will appear as visually appealing, cognitive processes are enhanced and lead to better learning scores (Mayer & Estrella, 2014; Plass, Homer, & Hayward, 2009). There is a number of different studies following this hypothesis.

Um, Plass, Hayward, and Homer (2012), for example, tested if an emotional design versus a neutral design is able to foster learning. Results showed that the emotional design evokes positive

* Corresponding author. E-Learning and New Media, Faculty of Humanities, Technische Universität Chemnitz, Straße der Nationen 12, 09111 Chemnitz, Germany.
E-mail address: sascha.schneider@phil.tu-chemnitz.de (S. Schneider).

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emotions, which in turn fostered cognitive processes and learning performance. In a study by Plass, Heidig, Hayward, Homer, and Um (2014), students had to learn how viruses attack cells. Results indicate that an emotional design, again, fosters comprehension, although transfer scores were not affected. Mayer and Estrella (2014) examined students studying an animation (5 min) on how viruses cause a cold with either emotional design (colors, faces) or neutral design (black/white, no faces). The emotional design group scored best on learning tasks, with medium effect sizes ($d = 0.69$, $d = 0.65$). Three hundred and thirty four students of a study by Heidig, Müller, and Reichelt (2015) had to learn different learning materials altering in its design (classical vs. expressive) and usability (high vs. low). Results show that aesthetics and usability affected emotional states and positive states led to better learning outcomes and a higher intrinsic motivation. With the help of eye-tracking, Park et al. (2015) experimentally observed induced emotions (positive vs. neutral) while the learning material was changed in its design (with vs. without anthropomorphisms). Students with an induced positive emotional state had better comprehension and transfer scores and showed longer fixations on verbal information. However, just a few design features have been tested to function as emotional design features.

3. The role of decorative pictures in emotional design

Experiments have shown that learners learn better with verbal and pictorial representations instead of only verbal information (Mayer, 2010). According to Carney and Levin (2002), pictures serve five different functions. Four of these functions are supposed to support learning directly: representation, organization, interpretation, and transformation. A fifth function – decoration – does not have any relationship to the content of the learning text. Although decorative pictures lack on information concerning the learning tasks, they are examined to have only less to detrimental effects on learning in literature (Rey, 2012, 2014; Sung & Mayer, 2012).

In this study, illustrations in multimedia environments are split into two main dimensions: informative pictures and decorative pictures (see Fig. 1). Whereas informative pictures are directly concerned with the support of the learning process, decorative illustrations might foster or hinder learning (Magner, Schwonke, Aleven, Popescu, & Renkl, 2014). For this, decorative pictures are divided into two separate dimensions.

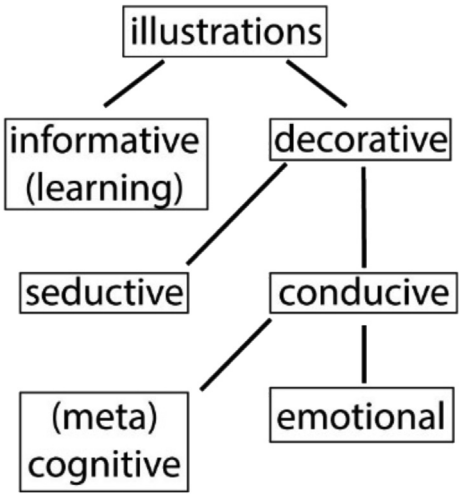

Fig. 1. Classification of illustrations within multimedia learning environments.

3.1. Seductive decorative pictures

There are, at least, some decorative pictures that might lead to an increase of cognitive load or distract students' attention (Harp & Mayer, 1998; Mayer, Griffith, Jurkowitz, & Rothman, 2008; Park, Moreno, Seufert, & Brünken, 2011; Schnotz, Fries, & Horz, 2009) and, therefore, decrease learning performance. These pictures are further called seductive (decorative) illustrations. Seductive illustrations and the accompanying seductive detail effect, which states that additional irrelevant but interesting learning materials impair learning performance, are examined with a large number of studies so far. In a meta-analysis by Rey (2012), results show that either retention performance ($d = 0.95$) or transfer performance ($d = 0.83$) is negatively affected by the insertion of seductive pictures. In four different experiments by Harp and Mayer (1998), six seductive illustrations were added to a text accompanied with learning pictures, which was about the process of lightning formation. All of these additional pictures contained consequences of lightning with frightening and gloomy moods (not tested). Results in each experiment showed that participants with seductive pictures did worse on retention and transfer scores. Bartsch and Cobern (2003) replicated this finding by inserting seductive illustrations on ten of thirty PowerPoint slides, whereas no pre-test on the emotional content of the pictures is reported. Seductive picture were also found to impair learning performance and distract attention in two experiments by Sanchez and Wiley (2006). Pictures were pre-tested for their emotional interest but not on their valence or arousal. It was further shown that seductive illustrations hindered learning success for students with low prior knowledge (Magner et al., 2014). Again, this study did not report any pre-test on emotional valence. In consequence, all the studies that have been described for seductive pictures suffer from methodological different issues: (1) None of the seductive details were checked on their emotional valence and arousal, (2) only few of the seductive details were intertwined logically with the learning environment, (3) none of the seductive details were designated as seductive for learners, and (4) no picture was checked on its metacognitive impact. These four issues might explain inhibiting learning effects of seductive illustrations and, if checked for, might lead to a creation of conducive decorative pictures. Two of these issues will be addressed in this study – the valence and metacognitive impact of decorative pictures, while the other two are controlled for.

3.2. Conducive decorative pictures

There might be decorative pictures that increase learning mediating factors like positive emotions or interest (Lenzner, Schnotz, & Müller, 2013; Sitzmann & Johnson, 2014) and, therefore, increase learning (Chang & Choi, 2014). These pictures are further called conducive (decorative) illustrations. Conducive illustrations can be distinguished between two or even more subcategories, a separation that is close to the cognitive interest and emotional interest theory from Kintsch (1986), which was also used by Park and Lim (2007).

The first subcategory is called *(meta-)cognitive (conducive decorative) illustrations* and is supposed to enhance learning mediating processes like cognition and metacognition, such as summary illustrations (Harp & Mayer, 1997), pictorial metaphors (McKay, 1999), or any pictures that enhance metacognitive processes (Ahmad, Ohsawa, & Nishihara, 2011). Other forms of pictures might support retrieval and function as retrieval cues (Unsworth, Spillers, & Brewer, 2010). In particular, metacognitive decorative pictures might activate retrieval processes within working memory so that these pictures are linked to verbal information (Khader, Burke, Bien, Ranganath, & Rösler, 2005). This link between

pictures and learning information could form a *compound cue* (Schneider & Logan, 2009) and lead to a more effective knowledge representation according to theories on neural networks (McClelland & Chappell, 1998). On the other hand, decorative pictures might foster goal orientation (Chen & Latham, 2014). In the latter study, for example, a decorative picture of Rodin's "The Thinker" led to significantly higher task performance in comparison to a control group without this picture. In our study, pictures show a group of students in either a lecture hall or a leisure time situation will serve as a priming for learning context. This induction of context relation within the phase of knowledge acquisition might be helpful for those receiving pictures with the same context (learning context) as participants of this study have to learn in a similar situation as those on the university context pictures according to studies on context-dependent memory (Smith & Vela, 2001). Showing a university context can increase a feeling of being in a formal learning situation and thus a feeling of higher dominance. This might lead to a higher effort in learning the facts of the learning content.

The second subcategory is called *emotional/motivational (conducive decorative) pictures* and consists of pictures that evoke emotional and/or motivational states (Bradley, Codispoti, Cuthbert, & Lang, 2001). These pictures might serve as a priming of affect or motivation (Topolinski & Deutsch, 2013). A first series of experiments by Lenzner et al. (2013) showed that the implemented decorative pictures have only minor distracting effects, but this small amount of attention was enough to induce better mood, alertness and calmness. Furthermore, results indicate that a perceived difficulty of learning materials can be reduced by some decorative pictures and, in combination with learning pictures, these pictures were able to enhance learning performance. While further results showed that emotional-interest pictures showed less enhancement of learning than cognitive interest pictures, their impact on learning was as good as a verbal-only condition so that no seductive detail effect occurred (Park, Kim, Lee, Son, & Lee, 2005). Emotional conducive pictures are examined to catch viewers' attention, but also, to promote further attentional engagement (Calvo & Lang, 2004; Nummenmaa, Hyönä, & Calvo, 2006). Additionally, positively valenced pictures are able to lower negative affect, what, in turn, increases learning performance (Sitzmann & Johnson, 2014). It is not clear what kind of affect will be most helpful in this context, however, it can be assumed that a positive valence leads to higher scores of pleasure, which, in turn, might reflect a tendency to approach the learning stimulus (Bradley & Lang, 1994). Moreover, unpleasant or negatively valenced pictures might lead to an increased defense behavior, which decreases the activation of coping with the rest of the material – a feeling of reduced arousal (Lang, Bradley, & Cuthbert, 1997).

Summarizing these studies, learners might show higher learning results when a positive emotional state or metacognitive support is induced by the design of the learning materials. Previous studies in this field have primed emotions via anthropomorphisms (Park et al., 2015), or color combinations and shapes (Um et al., 2012). Metacognitive support has been primed by a reflection-inducing sceneries (Chen & Latham, 2014) or metacognitive prompts (Bannert, Sonnenberg, Mengelkamp, & Pieger, 2015). Within this experiment, the valence and displayed learning context will be examined as examples for emotional and (meta-)cognitive conducive picture. These pictures are supposed to change not only learning performance, but also affective dimension like pleasure, arousal, and dominance (Mottet & Beebe, 2002). These dimensions will be examined as mediating variables.

4. The present experiment

In the present study, emotionally valenced pictures will serve as a possible operationalization of emotional/motivational conducive pictures. These pictures will be changed by the facial expressions and gestures of the shown extras – a procedure that is often used to manipulate emotions (Cowie et al., 2001). With this manipulation, the present experiment explores if emotionally valenced (decorative) pictures are able to induce affective states and thus foster learning performance:

H1. Students with positive-affective decorative pictures in their learning materials will have higher learning scores (retention and transfer) than students with negative-affective decorative pictures.

On the other hand, we were interested to find out if decorative pictures are influenced by their context relation – for example, a separation between shown learning situations (e.g. students in a lecture hall, learning-context related pictures) as context-dependent cues or leisure situations (e.g. students in a cafeteria, leisure-context related pictures) context-independent cues. These picture will serve as a possible operationalization of (meta-) cognitive conducive pictures.

H2. Students with learning-context related decorative pictures in their learning materials will have higher learning scores (retention and transfer) than students with leisure-context related decorative pictures.

In addition, we would like to examine if there are any interactions between the affective state of decorative pictures and their metacognitive impact through context relation concerning learning performance. Moreover, the constructs of pleasure, arousal, and dominance are examined as possible mediators or additional dependent variables.

5. Method

5.1. Participants and design

The participants were 85 university students from the Technische Universität Chemnitz, who received either 6 € or a one hour course credit, whereas 53% of all participants received a course credit. Three students had been excluded due to technical problems. Fifty-nine female and twenty-three male students remained for further analysis. The mean age was 24.2 years ($SD = 3.6$). Students are enrolled in media studies (37%), intercultural studies (11%), psychology (11%), and others (23%). The mean knowledge score based on the prior knowledge questionnaire described in the learning tasks section was 1.31 out of 6, what can be seen as a rather low prior knowledge. Furthermore, there were no significant differences between the four treatment groups in terms of age ($p = .43$), gender ($p = .61$), subject of study ($p = .31$), course credit ($p = .25$), or prior knowledge ($p = .97$). Each student was randomly assigned to one cell of a two (positive affective vs. negative affective) × two (leisure-context vs. learning-context) between-subjects factorial design, so that almost equal group numbers were achieved.

5.2. Materials

The learning material consisted of 1317 words and ten instructional graphics. This bimodal medium explained what cell division means and which mechanisms are responsible for it. The text consists of explicit declarative facts and concepts and was derived from several school and university books concerning biology and

double-checked by two biology teachers and one Ph.D. of biochemistry. This learning material was separated into four segments: “Concepts”, “Interphase”, “Mitosis”; and “Cytokinesis” and titled with “One becomes two – the division of eukaryotic cells”. Segment 1 consisted of two text pages about the structure of cells and how DNA is involved (each text page included one learning picture), the second segment explained the stages within the interphase with the help one text page and one graphic, the third segment described all five sub-phases with three text pages and five informative pictures, and, finally, the fourth segment involved the last phase within the division of cells by contrasting animal and plant cells with the help of one text page and two pictures. To read all text pages, participants had to navigate via a main page (see Fig. 2). Each segment was displayed by its segment title and one picture. These four pictures reflect the operationalization of the experimental group. Students were told before they started the experiment that these pictures are only used as navigational buttons but do not consist of information to be learned. This procedure addresses issue (3) of seductive decorative details. Each picture displays the same three people (two women and one man) in either a learning situation (an auditorium at university) or a leisure time situation (a sofa within a student's club) and either positive affective facial expressions and postures, or negative affective representations (for comparison, see Fig. 2). For this, 23 pictures had been pretested by six students. Each picture had been shown in combination with three items. Students had have to rate each item on a 7-point scale. The first item asked how positive or negative a picture can be assessed. The second item had questioned how much a picture can be assessed as displaying a learning scenario. The third item measured how much a picture can be assessed as leisure context. Inter-rater reliabilities for item 1 ($\alpha = .99$), item 2 ($\alpha = .99$), and item 3 ($\alpha = .99$) can be assessed as very high. In addition, means had been computed for each item in order to sequence all items. The first experimental factor (positive vs. negative valenced pictures) differed significantly among item 1 ($p < .001$, $\eta_p^2 = .89$) and the second factor (school context or leisure context pictures) differed among item 2 ($p < .001$, $\eta_p^2 = .97$), and item 3 ($p < .001$, $\eta_p^2 = .96$). For each experimental group, four pictures were chosen which reached highest means on the relevant scales. With these analyses, the methodological issues (1) and (4) of seductive decorative pictures research will be addressed.

Overall, the learning web pages included a starting page, a menu page, with several subpages, and an exit page (for an overview, see Fig. 2). The menu page could not be started before a pre-opened window was filled in with an identification code. After filling out this gap and pressing a “forward”-button, the menu page included the above mentioned four pictures as buttons for all four segments, which led to learning pages, and an exit button to move on to the second questionnaire. The learning pages are followed by an extra page with the corresponding picture as a button on the menu page. The inclusion of decorative pictures addresses issue (2). Moreover, every web page was headlined by a small grey bar which includes the remaining time on the learning environment pages. This time bar was pre-set with 25 min according to the mean of three reading time pre-tests with text laypersons. Once this timer had expired, students saw an extra page, where they were told to continue with the second questionnaire by clicking on a button below the instruction.

Fig. 2. Selected frames from the web-based learning environment on cell division with four conditions of decorative pictures on the main page: Learning context with positive mood (top left), learning context with negative mood (bottom left), leisure context with positive mood (top right), or leisure context with negative mood (bottom right). Note that each participant only saw one condition of pictures. The main page includes four sub-topics as picture buttons and a 5th button (below pictures) to leave the learning environment if ready.

The whole experiment was separated into three parts, a first questionnaire, the learning pages, and a second questionnaire. Each part is linked to the next without the need for students to open or close browser pages and the identification code was required in each part. The first questionnaire was used to solicit information concerning their age, gender, study subject, and three questions about their prior knowledge. On a separate page, participants were then instructed to click on a link to another web page, enriched with all information of the coming learning subject. Moreover, students were told to carefully read all verbal information and view all pictures: "Please try to memorize all textual and pictorial information as good as you can!" This page also included information about the structure of the learning environment with an extra notice on the pictures, which can be used as links but do not contain any information (manipulation pictures). If students had finished their learning pages, they were automatically led to the second questionnaire and instructed on a first page that no "go back"-button exists during the questionnaire and that missing information will be marked with red color. In order to measure the emotional dimensions of *pleasure* ($\alpha = .83$), *arousal* ($\alpha = .80$), and *dominance* ($\alpha = .77$), a 18-items semantic differential scale (SDS; Russell & Mehrabian, 1977) followed on a separate page together with a 9-point scale for each item. When this questionnaire had been finished, the next pages showed different kinds of retention and transfer questions (one question per page). In the end, five questions tested how the experimental condition is still conscious among student's perception (manipulation check). Each question was equipped with a 7-point scale ranging from "I totally disagree" to "I totally agree". The wordings of these items have been translated for this paper: (1, leisure context) "The pictures on the menu page showed leisure time situations", (2, school context) "The pictures on the menu page show learning situations", and (3, positive mood) "The pictures on the menu page conveyed positive mood". Items 1 and 2 were prepared in order to check, that leisure time pictures are assessed as significantly more precise illustrations of leisure time situations and learning pictures are estimated as significantly closer to learning situations. Another two items in this questionnaire were implemented in order to check if any of these pictures are seen as more close to the content than its opponents, (item 4, theme relatedness): "The pictures on the menu page are well suited to the content of the learning material", or if any of these pictures irritated significantly more, (item 5, learning distraction): "The pictures on the menu page distracted me from learning all facts about cell division". These two items are included in order to separate all included decorative pictures from the definition of seductive details. All five items will be checked before the analysis of the hypotheses. On a final page, students were instructed to leave all browser pages open and signal the completion of all tasks to the experimenter.

5.3. Tasks and scoring

Prior knowledge was tested by three open questions ($\alpha = .70$) about the function of DNA and cell division: (1) "What is the function of DNA?", (2) "What is mitosis?", (3) "Which phases does a cell go through during mitosis?". These questions were analyzed by two independent raters, who were blind to the instructional conditions, with a pre-set of possible answers. The raters of these questions can be seen as reliable due to sufficient inter-rater reliability ($\alpha = .90$). If any of these pre-set definitions for question (1) and (2) are given or explained in a proper way, one point was given, otherwise zero points. For each correct phase named at question 3, one point was given. This makes a maximum of four points for question 3 and a maximum of six points for all questions.

As mentioned above, learning performance was measured by two performance tests – retention and transfer. All performance tests are shown in the appendix. Retention performance ($\alpha = .68$) was measured by seven multiple choice (MC) questions with four answering options and three graphic-labeling (GL) tasks in order to measure verbal and picture knowledge. The right answer of each MC question could be found in the learning texts and graphics, so participants just need to remember the facts they read before. The number of correct answers varied among all MC questions from only one to four. Each correct answer was rewarded with half a point – a maximum of two points for each question and fourteen points for all MC questions. The group of GL questions consisted of three graphics. The first graphic showed a eukaryotic cell, where five cell components were marked with labeling lines and different numbers. The second graphic showed a segregation of chromosomes into DNA strands. For this picture, three labels had to be entered. The third pictures showed the circle of steps throughout cell division. The first step was already filled, but students need to label all six remaining steps. For this, a list of appropriate words had been made a priori to be able to check answers. Each correct answer was awarded with half a point, so students were able to score a maximum of seven points. Retention performance was calculated as the sum of points of all MC and GL retention tasks (maximum amount: 21 points).

In order to measure transfer performance ($\alpha = .64$), four different kinds of questions were prepared. Two questions showed microscope images, which had to be categorized as one cell division phase. For this, four possible answers are shown beneath each image. Two points were given if the correct and no incorrect answers were marked in order to attach specific weight to the complexity and difficulty of these tasks. Two multiple choice questions were displayed afterwards, which asked for the connection between cell division and hereditary diseases like "What are possible factors that cause mutations (changes to genotypes)?" Again, four answers are shown beneath and each right mark was rewarded with half a point. Subsequently, a cloze test was displayed. In a short text, six gaps had to be filled in. For this, fourteen words are shown above (43% right answers). Each correctly chosen word was rewarded with half a point, in sum three points as maximum reward for this task. Finally, the last transfer question consisted of two microscopic images – one eukaryotic cell and one prokaryotic cell. Students had to decide which image fits to each classification. Each correct answer was rewarded with half a point, in sum, one point for the whole question. Transfer performance was calculated as the sum of points of all transfer tasks (maximum amount: 12 points).

5.4. Procedure

The study was conducted in a computer lab with 25 work stations. Students were assigned to one of the four experimental groups by drawing lots. Group sizes were controlled by the experimenter in order to achieve almost equal numbers in each group. Depending on enrollment numbers of a student's experiment calendar, each accomplishment of an experiment consisted of one to ten students. A corresponding number of computers had been prepared by opening the first experimental web page before each experiment started. After each student filled out an identification form, which enabled the participants to quickly fill in this code when needed, all participants were instructed to follow the instructions on their screens, fill every gaps and read all information carefully. All students completed the three parts autonomously and after they reached the last page, they need to fill out a participants list at the experimenter's table to reward them with either a credit of one hour's participation, which is needed to complete their studies, or a certain amount of money.

6. Results

6.1. Manipulation check

Two one-factorial analyses of variance (ANOVAs) were conducted with context (school context vs. leisure context) as between-subjects factor and answers of manipulation check items *leisure context* and *school context* as dependent variables. Results of the first ANOVA show that learners in the group with leisure context pictures ($M = 5.60$, $SD = 1.72$) significantly differed from those in the group with school context pictures ($M = 1.86$, $SD = 1.16$) on *leisure context*; $F(1, 80) = 134.48$, $p < .001$, $\eta_p^2 = .63$). With the second ANOVA, it also can be shown that the group with leisure context pictures ($M = 2.75$, $SD = 2.05$) significantly differed from those in the group with school context pictures ($M = 6.08$, $SD = 1.39$) on *school context*; $F(1, 80) = 74.63$, $p < .001$, $\eta_p^2 = .48$). The third ANOVA was conducted with affect (negative vs. positive) as between-subjects factor and answers of the manipulation check item *positive mood* as dependent variable. Results show that learners in the group with negative affective pictures ($M = 3.07$, $SD = 1.82$) significantly differed from those in the group with positive affective pictures ($M = 5.41$, $SD = 1.30$) on this item; $F(1, 80) = 44.79$, $p < .001$, $\eta_p^2 = .36$). A multivariate analysis of variance (MANOVA) was conducted with context and affect as between-subjects factors and scores from the items *theme relatedness* and *learning distraction* as dependent variables. No significant effects were found for context, (Wilk's $\Lambda = .97$), $F(2, 77) = 1.20$, $p = .31$, $\eta_p^2 = .03$, affect, (Wilk's $\Lambda = .99$), $F(2, 77) = 0.32$, $p = .73$, $\eta_p^2 = .01$, or any interaction, (Wilk's $\Lambda = .99$), $F(2, 77) = 0.48$, $p = .62$, $\eta_p^2 = .01$. Statistically, the null hypothesis can be accepted for an effect size of $f = .10$ and $\alpha = .05$, because of sufficient power ($1 - \beta = .91$ for $\alpha = .05$). With these results, manipulation can be seen as confirmed and further analyses are permitted.

6.2. The influence of affective and context-related pictures on learning scores

In order to check all hypotheses, a multivariate analysis of covariance (MANCOVA) was conducted, with affect and context as between-subjects factors, prior knowledge scores as covariate, and retention and transfer scores as dependent measures. All pre-defined test assumptions have been met, Box's M (9, 69018.67) = 18.08, $p = .05$. Significant main effects were found for affect, (Wilk's $\Lambda = .90$), $F(2, 77) = 4.49$, $p = .017$, $\eta_p^2 = .10$, and for context, (Wilk's $\Lambda = .86$), $F(2, 77) = 6.48$, $p = .005$, $\eta_p^2 = .13$, whereas no significant effect of the covariate, $p = .59$, $\eta_p^2 = .01$, and the interaction, $p = .29$, $\eta_p^2 = .03$, occurred. Statistically, null hypothesis for the interaction can be accepted for an effect size of $f = .10$ and $\alpha = .05$, because of sufficient power ($1 - \beta = .91$ for $\alpha = .05$).

This test was divided into several followed-up analyses of covariances (ANCOVAs) for retention and transfer learning performance as dependent variables, and affect or context as between-subject factor. Regarding the difference between positive and negative affect, retention scores show significant differences, $p = .011$, $\eta_p^2 = .08$. The same significant difference can be seen within the transfer performance, $p = .038$, $\eta_p^2 = .06$. Regarding the context relation of the pictures, retention results differ significantly, $p = .008$, $\eta_p^2 = .09$. A significant difference for transfer performance could be revealed, $p = .008$, $\eta_p^2 = .09$. Interaction analysis did not reach significance for retention, $p = .12$, $\eta_p^2 = .03$, or transfer scores, $p = .36$, $\eta_p^2 = .01$. In addition, analyses of the covariate prior knowledge did not reach significance for retention, $p = .42$, $\eta_p^2 = .008$, or transfer, $p = .39$, $\eta_p^2 = .01$. Descriptive results are displayed in Table 1. Taken together, these results confirm hypotheses 1 and hypothesis 2.

6.3. Mediating effects of pleasure, arousal and dominance

After demonstrating the effects of valence and the portrayed learning context of illustrations on learning performance, the effects of all pre-supposed mediators (pleasure, arousal, dominance) will be analyzed. For this, a single learning performance was calculated by the sum of retention and transfer scores, which will be used as independent variable. In order to check all predefined assumptions for mediation analyses (Baron & Kenny, 1986), correlations among all dependent, independent and covariate variables were calculated (see Table 2). Since all mediators need to significantly correlate with learning performance, only pleasure will be included in the mediation analysis. As only the independent variable valence is significantly correlated with pleasure, no mediation analyses can be computed with portrayed learning context as independent variable.

For this, a series of regression analyses according to Preacher and Hayes (2008) and Hayes and Preacher (2014) was run to explore the role of pleasure in mediating the learning performance in the two manipulations of valence (see Fig. 3). Valence had a direct effect on transfer (c; $\beta = 1.91$, $t = 2.70$, $p = .009$) and a direct effect on pleasure (a; $\beta = 1.15$, $t = 5.85$, $p < .001$). The effect of pleasure on learning performance (b) was also significant ($\beta = .85$, $t = 2.13$, $p = .036$). Moreover, there was no partial effect of the covariate prior knowledge on learning performance (d; $\beta = .54$, $t = 1.47$, $p = .146$). Last, the direct effect of valence on learning performance, controlling for pleasure is not significant (c', $\beta = .91$, $t = 1.13$, $p = .262$), suggesting a full mediation, as defined by Baron and Kenny (1986). This indirect effect (ab; $\beta = .97$) can be seen as significant, $p = .03$ (test of the indirect effect calculated using the partial posterior p value; see Biesanz, Falk, & Savalei, 2010).

All other dependent variable, which did not account for the mediation process, were analyzed with a MANOVA, with affect and context as between-subjects factors, and, arousal and dominance as dependent measures, in order to check for group differences. All pre-defined test assumptions have been met, Box's M (9, 69018.67) = 17.48, $p = .05$. Significant main effects were found for either affect, (Wilk's $\Lambda = .82$), $F(2, 77) = 8.38$, $p = .001$, $\eta_p^2 = .18$, or context, (Wilk's $\Lambda = .69$), $F(2, 77) = 17.27$, $p < .001$, $\eta_p^2 = .31$, but not for the interaction, $p = .18$, $\eta_p^2 = .06$. Statistically, null hypothesis for the interaction can be accepted for an effect size of $f^2 = .15$ and $\alpha = .05$, because of sufficient power ($1 - \beta = .86$ for $\alpha = .05$).

Regarding the scores of arousal, significant differences for both, affect, $p < .001$, $\eta_p^2 = .18$, and context relation, $p < .001$, $\eta_p^2 = .25$, can be observed. Among the scores of dominance, no significant differences between affective groups occurred, $p < .84$, $\eta_p^2 < .01$. As calculated above, null hypothesis can be accepted. However, learning and leisure related groups differ significantly, $p = .001$, $\eta_p^2 = .13$. Descriptive results are displayed in Table 1.

7. Discussion

The aim of this study was to investigate if decorative pictures might serve as either an emotion facilitator and thus might enhance learning performance, or if decorative pictures might serve as a kind of metacognitive facilitator and thus enhance a willingness of learning new information resulting in higher learning performance. For this, decorative pictures on a navigation page of a learning environment have been modified in their contents towards their emotional level (positive vs. negative) or context (learning vs. leisure). A manipulation check showed that the counterparts of emotional valence (negative & positive) were achieved by these pictures and that students did perceive the difference between learning and leisure pictures. Results show that positive and learning-context decorative pictures enhance both learning

Table 1
Mean score on retention, transfer, pleasure, arousal, and dominance and their corresponding standard deviations for the four different groups (positive affect and learning context, positive affect and leisure context, negative affect and learning context, or negative affect and leisure context).

Group			Type of test									
			Retention		Transfer		Pleasure		Arousal		Dominance	
Affect	Context	N	M	SD	M	SD	M	SD	M	SD	M	SD
–	Learning	21	16.17	1.83	8.57	1.64	5.25	0.78	3.69	0.90	5.57	0.83
–	Leisure	20	13.90	2.37	7.45	1.33	5.24	0.84	4.32	1.19	5.08	0.72
+	Learning	21	16.74	2.50	8.95	1.13	6.50	0.91	4.10	0.90	5.71	0.70
+	Leisure	20	16.03	2.45	8.35	1.18	6.28	1.00	5.60	0.68	4.85	1.23

Note. All displayed scores are not adjusted for prior-knowledge. Positive affect is indicated with "+" and negative affect with "−". Retention scores ranged from 0 to 21, transfer scores ranged from 0 to 12, pleasure, arousal, and dominance ranged from 1 to 9 (the higher the score, the higher the retention or transfer).

Table 2
Correlations among all independent and dependent variables, and prior knowledge as covariate.

Variable	1	2	3	4	5	6	7	8
1. Valence	–							
2. Learning Context	.00	–						
3. Prior Knowledge	.05	.17	–					
4. Retention	.26*	.30**	.14	–				
5. Transfer	.22*	.30**	.15	.42**	–			
6. Learning Performance	.29*	.35**	.17	.92**	.74**	–		
7. Pleasure	.55**	.06	.03	.34**	.22*	.35**	–	
8. Arousal	.36**	−.46**	−.08	.16	.03	.13	.19	–
9. Dominance	−.02	.36**	.15	.06	.11	.09	.23*	−.27*

Note. $N = 82$ for all measures. * indicates $p < .05$. ** indicates $p < .01$.

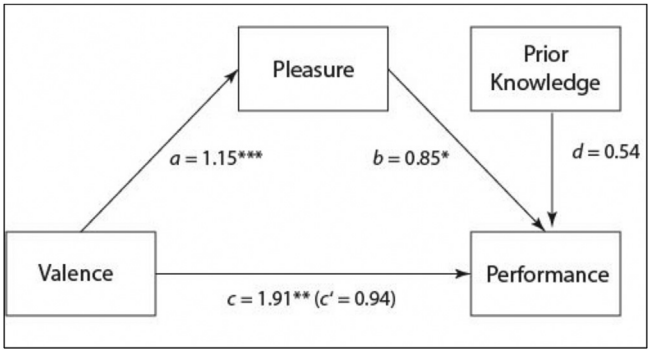

Fig. 3. Mediation Process for valence as independent variable, learning performance as independent variable, pleasure as mediator, and prior knowledge as covariate. *Note.* Valence was coded with positively valenced pictures as 1 and negatively valenced pictures as 0. All given scores are β-coefficients. * indicates $p < .05$. ** indicates $p < .01$. *** indicates $p < .001$. Scores without * are not significant.

performances, retention and transfer, with medium effect sizes (Cohen, 1988), more than negative pictures and leisure context pictures, with medium to high effect sizes. Moreover, positive pictures are shown to increase the perception of pleasure and arousal, whereas learning pictures are revealed to enhance arousal and dominance subscales.

Concerning learning performance, positive pictures were shown to enhance both, recall and transfer. In addition, no interaction effects between the manipulation of portrayed learning context and emotional content of pictures were found, although only the group with leisure context pictures and a negative mood scored descriptively worse than the other groups.

The multifarious results within the SDS help to gain deeper insights in our manipulation of emotional content and the interaction with a learning oriented setting. The increased scores on the pleasure scale within the positive affective material groups is in line with our predictions that positively valenced pictures might induce certain positive emotions and therefore strengthen our assumptions of how emotional content can be implemented. Mediation analyses shows that positively valenced pictures increase a feeling of pleasure and this increase leads to higher learning performance. Additionally, learning related pictures might increase the impression of a "push" towards learning and with this, subsequently the feeling of dominance. These results might have occurred as learning environments are sometimes more related to forms of competition and disciplinary measures of teachers (Frenzel, Pekrun, & Goetz, 2007), so it seems to be plausible that school context pictures generate higher assessments of dominance. Despite this negative connotation of learning pictures, students in this group outperformed leisure context pictures. This result might have occurred due to the motivational or metacognitive influence of school contexts (e.g. "I see other students learning, I will do the same") – a relation that should be investigated further. Students might be more familiar with school context pictures in these environments (Schneider, Nebel, Pradel, & Rey, 2015a) or it might be valuable to include current embodiment theories (Winkielman, Niedenthal, Wielgosz, Eelen, & Kavanagh, 2015).

Increased arousal was induced by the positive affective pictures within our experiment. One explanation could be derived from the mobilization-minimization-hypothesis (Taylor, 1991), which states that negative events produce a higher mobilization at first, but because of its negative nature, people tend to minimize memory processes and ratings on arousal later. A higher arousal of positive pictures might have led to a "motivated attention" (Olofsson, Nordin, Sequeira, & Polich, 2008), and thus could explain a deeper cognitive processing of accompanied learning information. A narrow point of view can be derived from Hanoch and Vitouch (2004), who state that "[h]igh emotional arousal states can be viewed as a vital mechanism allowing humans, despite their naturally limited resources and computational capabilities, to cope with the unpredictability and complexity of the environment."

Further insight can be gained from the higher arousal scores within the leisure context group in contrast to the learning pictures

group. An explanation can be derived from a more vivid feeling of emotions concerning leisure events. Students might have been more activated by the presence of a leisure context than by school contexts. On the one hand, leisure pictures increased the feeling of arousal, what is in contrast to the lowered learning outcomes. This might be due to the fact that the disturbed expectations, but not the content of the pictures (e.g., relaxation, fun, social interaction), caused this effect. This resulted in other cognitive processes than our manipulation of positive and negative affective pictures.

7.1. Implications

Within our theoretical framework and supported by our results of the scales addressing emotions, we provide a first approach how to classify pictures regarding their learning relevant content. There might be decorative pictures which influence learning processes in a positive way (conducive decorative pictures) and others which impair helpful cognitive processes (seductive decorative pictures). Especially the content of pictures within learning environment concerning affective and contextual dimensions was shown to influence learning. Future design of learning environments should be aware of these effects. Moreover, this is a first step into a deeper understanding of how decorative pictures influence learners in multimedia learning environments and might be especially important when addressing the difficulties of classifying pictures on a larger scale (e.g. search engines that try to classify pictures in order to make them traceable through text-based search). The examined facets of decorative show that emotional and cognitive processes are intertwined as other studies postulated before (Huk & Ludwigs, 2009). Our results regarding arousal and dominance provide useful implications for the design of emotional content in learning environments, as not every topic can be modified within a positive-negative paradigm. For example, a learning setting, teaching information about the victims of the holocaust, would be highly inappropriate if interspersed with very positive emotional pictures. Our findings suggest that there may be other methods to influence learning with pictures, like context, arousal or dominance, than only within this limited two-dimensional boundary of emotions. From a practical point of view, results have given a first evidence on how to improve learning results with decorative illustrations as most of the upcoming textbooks and learning materials in schools, universities and other educational domains include decorative pictures in order to supposedly upgrade their learning themes, however, the decorative pictures within this study might not be indirect context with the learning content.

7.2. Limitations

Our findings regarding the emotional impacts of our specific learning material manipulations must be generalized with caution, as we cannot assess a difference between seductive illustrations and conducive illustrations. Until now, we need to interpret this effect as categorization of seductive details. Moreover, cultural background might be an important moderator of the emotional impacts through pictures. Our positive leisure pictures might be rated as negative or disrespectful in other cultures and therefore provoke completely different outcomes. This might not only apply to cultures but the learning setting in general. For example, students might have a completely different perception of positive learning environment as pre-school teachers or management advisers.

Additionally, as we only used one method to induce emotional affects, we cannot compare our findings with other methods of provoking emotional states. In addition, the operationalization of the pictures might be done more precisely as the pictures differ in more than one detail. Furthermore, due to the relatively low reliability scores in the present study, more studies should be conducted with different learning contents, learning age groups, other measures (e.g. prior knowledge) and a differentiation of learning and leisure settings in order to strengthen the validity of the results.

7.3. Future directions

In comparing our results to studies with face-like shapes and objects as an element of emotional stimulations, we have to keep in mind that humanizing logical entities might not only affect emotions, but might also add certain abilities (e.g. interaction or movement) to the mental concept of these elements. This might have intervened with effects of emotional content. As we did not use this approach, we need to further elaborate the complex relationship between the placement of emotional stimuli (within the learning elements/in addition to learning elements), anthropomorphisms, and the impacts on perception of the learning content and the learning outcomes. Besides, it would also be helpful to examine the difference between the concepts of conducive and seductive decorative illustration within learning environments.

The experience of flow relies on an optimal balance of challenge and abilities and the expertise reversal effect indicates negative effects of methods that usually fosters learning (Nakamura & Csikszentmihalyi, 2014). Therefore, it remains unclear if adding pictures displaying learning contexts and positive emotional people might be inefficient or even harmful for experts as this might lower perceived difficulty and dominance. On the other side, a higher prior knowledge might influence a priming effect positively by a deeper processing of additional illustrations due to less needed time on the processing of the learning material (Lee, Kalyuga, & Wales, 2014). This is just one example for the intrapersonal differences that might take place during emotionally charged learning and need further elaboration. It might be further interesting how this effect interacts with other individual or cultural variables within the context of multimedia learning (Schneider, Nebel, Pradel, & Rey, 2015b).

As the group with negative emotional content and leisure related pictures descriptively resulted in the lowest learning outcomes, further empirical data is needed to contrast this group with positive leisure and negative learning settings in greater detail. Future studies should investigate different kinds of learning-related emotions in pictures and their influence on motivational, cognitive, and metacognitive processes. Through this, we could gain deeper insight how emotions do their work while processing new information.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.learninstruc.2016.03.002.

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