Emotional Design in Multimedia Learning

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Can positive emotions experienced during multimedia learning facilitate cognitive processing and improve cognitive and affective outcomes? 118 college students were randomly assigned to four experimental treatment conditions created by two design factors for the induction of positive v. neutral emotions, (1) by means of a self-referencing mood induction procedure, and (2) through the emotional design of the learning material. Results showed that the emotional design of the materials can induce positive emotions in learners, and that these positive emotions improved cognitive learning outcomes, motivation, satisfaction and perception toward the materials. The study suggests that emotional design should be considered an important factor in the design of educational materials.

Can positive emotions facilitate cognitive processing and improve cognitive and affective outcomes in multimedia learning? Effects of emotions on human behavior can be seen in all aspects of our lives – from advertisement to political campaigns and from personal interactions to professional communication. Positive emotions in particular are attributed long lasting effects on the personal growth of individuals and their social and emotional well-being (Fredrickson, 2001). When it comes to designing educational experiences, however, little is known about how the emotional impact of learning materials on the learner may affect learning outcomes. In the present study, we therefore investigate whether multimedia learning environments can be designed to induce positive emotions in learners, and whether these positive emotions enhance comprehension of the multimedia materials and facilitate transfer of the new knowledge.

On the most fundamental level, hypotheses on the impact of emotions on learning are based on the definition of emotions and their effect. From a cognitive perspective, emotions are generated by the individual’s judgment about the world and initiated by an individual’s appraisal of his or her circumstances, and the experience of emotions includes various cognitive components including the activating appraisal, subsequent desires, and intentions (e.g., Arnold, 1960; Frijda, 1993; Lazarus, 1991; Oatley & Johnson-Laird, 1987). Specifically, emotions are described as a “complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal directed, and adaptive” (Kleinginna & Kleinginna, 1981, p. 355). Compared to moods, which are longer lasting and harder to change in the short term, emotions can change behavior over a relatively short term and last for short periods.
There is indication that positive emotions and negative emotions play different roles in cognitive processes. Based on the personality systems interaction theory, Bolte, Goschke, and Kuhl (2003) argue that positive and negative emotions are accompanied by qualitatively different information processing models. According to their approach, an increase in positive affect supports a holistic processing mode, which is characterized in memory by the activation of wide semantic fields that include weak or remote associations. In contrast, an increase in negative affect supports an analytic processing mode, which is characterized by a more restricted spread of activation to close associates and dominant word meanings (Kuhl, 2000). Research suggests that negative affect, such as feeling anxious or endangered, helps focusing, i.e., it supports the ability to concentrate upon a topic, without distraction (Norman, 2004).

In the present research, we were interested in the effect of positive emotions on learning. Positive emotions have been studied as facilitating factors of enhancing cognition as well as changing individuals’ affective experiences, such as attitude and motivation. Yet other research found that an individual’s mood state impeded encoding and retrieving of information. In the following sections, we will first summarize this research on the effect of emotions on cognition. We will then discuss these findings in the context of cognitive theories of multimedia learning in order to derive hypotheses for the impact of positive emotions on learning.

**Positive Emotions and Cognition**

From a cognitive perspective, emotional experiences include various cognitive components. Emotions are generated by people’s judgment about the world and initiated by an individual’s appraisal, which is the output from the interaction of one’s concern and a stimulus (Desmet, 2003; Frijda, 1993; Lazarus, 1991; Oatley & Johnson-Laird, 1987; Ortony, Glore, & Collins, 1998). This means that learners’ emotions are generated by a cognitive process of appraisal and interaction with the learning environment, which includes the learning materials. How these emotions affect learners’ cognitive processes during learning has been the topic of discussion by various researchers.

There are two competing hypotheses for the effect of positive emotions on cognition. The facilitation hypothesis suggests that positive moods facilitate performance on divergent, creative problem solving tasks (Isen & Baron, 1991; Erez & Isen, 2002; Konradt et al., 2003). In contrast, the suppression hypothesis suggests that moods can take extra-task processing or task-irrelevant processing and will have a negative effect on reasoning (Oaksford, Morris, Grainger, & Williams, 1996).

**Facilitation hypothesis of positive emotions**

There are several types of relevant positive emotions, such as confident, intriguing, epiphany, enthusiastic, excited, hopeful, curious, enlightened, thrilled, anticipatory, comforting, interesting,
insightful, satisfied and calm that are assumed to help learners focus on their task performance (Kort, Reilly, & Picard, 2001). A series of research studies has suggested that positive emotions have a crucial effect on diverse cognitive processes such as information processing, communication processing, negotiation procession, decision-making processing, category sorting tasks and even the creative problem-solving process (Isen & Baron, 1991; Erez & Isen, 2002; Konradt et al., 2003).

Isen and her colleagues identified two mechanisms in support of the facilitation hypothesis. One factor they identified is a long-term memory factor. Positive affect can serve as a retrieval cue for positive material from long-term memory. For example, participants recalled more possible functions for an object from long-term memory when in a positive mood (Isen et al., 1987). Isen, Shalker Clark, and Karp (1978) found that a positive mood state serves as an effective retrieval cue for other positive materials in memory.

The second factor involves the way information is processed rather than how it is retrieved. Positive mood may affect cognitive processes themselves and not just the resources available for those processes. In other words, positive affect should be viewed as influencing the way in which material is processed, rather than just influencing the amount of processing capacity. Isen and Daubman (1984) and Isen, Johnson, Mertz, and Robinson (1985) suggested that positive affect influences cognitive organization and creativity. These studies showed that positive affect provides cues to the positive material and influences cognitive organization by altering the context in which cognitive activity take place. They suggested that cognitive processes may be more flexible as a function of positive affect, which may also result in greater creativity and improved problem-solving ability (Isen, Daubman, & Nowicki, 1987). Other studies by Aspinwell and Taylor (1992) and Staw and Barsade (1993) did not examine the direct effect of positive emotions on learning, but implied that positive emotions might be facilitative factors that influence performance including social adjustment, decision-making and interpersonal skill.

Positive emotions have also been studied as direct or indirect factors in changing people’s other affective experiences such as attitude, judgment, evaluation and satisfaction (Isen et al., 1978; Isen & Patrick, 1983; Petty et al., 1993; Weiss et al., 1999). Overall, people who are in a positive emotional state make more positive judgments and give favorable feedback because they interpret situations more positively than they would at other times. The studies of Erez and Isen (2002) and Isen and Reeve (2005) also indicated that positive emotions facilitate intrinsic motivation by influencing the cognitive process involved in motivation.

Suppression hypothesis

The suppression hypothesis describes the opposite effect of positive emotions on cognitive process. The research of this negative effect of emotions started with the study of depressed mood.
Studies by Ellis, Thomas, and Rodriguez (1984) and Ellis, Thomas, McFarland, and Lane (1985) examined the effects of experimentally induced mood states on recall and retrieval of information. Both studies showed that mood state impeded encoding and retrieving of information. The studies explained these results within the framework of a resource allocation theory, asserting that mood state can both quantitatively reduce the amount of task-relevant processing by the participant and can produce a differential allocation of processing resources or capacity during encoding. Emotional states are viewed as conditions that regulate the allocation of capacity or resources in cognitive tasks. A disruptive mood state is considered generating task-irrelevant thinking that interferes with the encoding as well as the output of information because it requires cognitive capacity that would normally be allocated to the process of encoding the task (Pekrun, 1992a, Pekrun et al., 2002). This suppressive effect of positive emotions can also be explained within cognitive load theory (Pass, Renkl, & Sweller, 2003; Sweller, 1988; 1994), where emotions experienced during cognitive processing of learning materials can be viewed as imposing unnecessary load in working memory, i.e., can be interpreted as extraneous cognitive load.

Seibert and Ellis (1991b) suggested that this negative effect of emotions applies for positive as well as negative emotions, arguing that emotional states in general can impair performance. They suggested that positive mood may increase the demand on working memory because being happy tends to increase the incidence of mood-related thoughts that interrupt processing on a given cognitive task. A study by Oaksford et al. (1996) found that mood states also suppress the cognitive process in convergent or analytic tasks such as deductive reasoning.

Even though the facilitation hypothesis is dominant in research related to the effect of positive emotions on cognition, the effect of positive emotion in the learning process is still not well understood, and the implicit assumption by many researchers appears to be that emotions generally create unnecessary cognitive load and should therefore be minimized. We will therefore describe in the next section a theoretical foundation for the impact of emotions on learning that is based on cognitive theories of multimedia learning. We are interested in the question of how the design of the learning materials may be able to induce positive emotions during learning, and how the learners’ emotional state may in turn affect learning.

**Positive Emotions and Multimedia Learning**

For the purpose of this research, multimedia learning can be defined simply as learning from pictures and words (Mayer, 2001). The *Cognitive Theory of Multimedia Learning* describes, based on the dual channel assumption of *Dual Coding Theory* (Paivio, 1986), how multimedia information is processed in separate channels for verbal and visual information (Mayer, 2001). Learning is described as a generative process.
that includes the selection of relevant visual and verbal materials, organization of these visual and verbal mental representations in coherent structures in working memory, and integrating the visual and the verbal mental representations with one another and with prior knowledge (Mayer, 2005). Complementing this process model, the Cognitive Load Theory provides a capacity model for multimedia learning (Sweller, 1988, 2010). The theory describes three types of cognitive load, intrinsic cognitive load, which describes the complexity of the information, germane cognitive load, which describes the amount of mental effort invested by the learner in comprehending the materials, and extraneous cognitive load, which describes processing demands of information that is not directly related to the learning task, and which are a result of the instructional design of the materials (Kalyuga, 2010).

In the context of these models, emotions are typically viewed as a source of extraneous cognitive load that should be reduced as far as possible. Alternative theories suggest, however, that emotions may impact learning in a positive way, for example, by increasing learners’ interest and motivation. Below we will summarize related research for these two approaches.

Emotions as Extraneous Cognitive Load

This approach, which extends the suppression hypothesis described above to multimedia learning, suggests that the introduction of any elements aimed at inducing positive emotions will impose extraneous cognitive load, which might hurt learning. This approach is consistent with the Seductive Detail effect, which suggests that adding unimportant but interesting elements to expository texts impedes the learning of the main points in the text (Garner et al., 1978; Harp & Mayer, 1991).

The strategies used in many of these studies to induce positive emotions or interest in learners included the addition of interesting text or visual information to the learning materials. This information has to be processed as additional information, causing extraneous cognitive load. The relative benefit of this additional processing for the increase in learners’ interest and motivation was in many cases not high enough to result in enhanced learning.

However, other research suggests that interest in the subject and the perceived importance (task value) of the content have to be treated as separate constructs, and that adding information to make materials emotionally interesting may enhance learning (Sadoski, 2001; Schraw, 1998; Schraw & Lehman, 2001; Wade, Schraw, Buxton, & Hayes, 1993).

Facilitating Effect of Emotions

The impact of learners’ interest and motivation on learning is described by models such as the ARCS model, which suggests strategies for attention, relevance, confidence, and satisfaction of the learner (Keller, 1987). Strategies to enhance positive emotions (specifically, sympathy and pleasure), and
reduce negative emotions (specifically, fear, envy, and anger) in order to facilitate learning have been proposed by Astleitner (2000). Astleitner argued that emotions affect learning, and that instructional designers therefore need to optimize learners’ emotional states during the learning process. However, there is limited empirical support available for this approach. Most recently, Moreno and Mayer proposed an extension to the Cognitive Theory of Multimedia Learning that incorporates motivational and metacognitive factors as mediators of multimedia learning (Moreno & Mayer, 2007).

We base our approach to the impact of emotions on multimedia learning on the facilitation effect described above. Based on research that found a crucial effect of positive emotions on a variety of cognitive processes, including information processing, communication processing, negotiation procession, decision-making processing, category sorting tasks and even the creative problem-solving process (Isen & Baron, 1991; Erez & Isen, 2002; Konradt et al., 2003), we hypothesize that these effects will also result in enhanced learning.

We further include in our approach the cognitive-motivational mediation model developed by Pekrun, which describes the activation property of emotions. Positive emotions can be activating (happy, hopeful) or deactivating (satisfied, calm). Likewise, negative emotions can beactivating (anxious, angry) or deactivating (hopeless) (Pekrun et al., 2002; Pekrun & Jerusalem, 1996). Therefore, facilitating effects of positive emotions may be expected for those positive emotions that have an activating property.

Two Methods of Inducing Positive Emotions

A final consideration for this study on the impact of positive emotion on learning is the way in which emotions will be induced in the learner. In research on the effect of positive emotions, the desired emotional states have usually been induced using various treatments such as viewing films or giving a free gift before the task (e.g., Isen et al., 1987). However, there are limitations when applying these methods in a learning environment. For example, the duration of the emotional state and its effects are limited. By general definition, an emotional state is a relatively short-term state of mind. Usually, research in emotions uses short tasks that are typically completed within 10 minutes after the emotion state has been induced. Compared to those tasks, the learning in multimedia environments is a relatively long process that itself is likely to impact users’ emotional state. Therefore, if the emotional treatment is provided before the learning, it is uncertain as to how long the learner can maintain the initial emotional state as the learning process proceeds, and how much the initial emotional state will affect the learning process. In addition, it is of limited practical relevance for educators in schools that small gifts given before the learning task may enhance learning.

As an alternative mood induction approach, we pursued the idea that in multimedia learning environments, the learning material itself can be the major factor that stimulates users’ emotions. In
designing multimedia-based learning, various studies have implied that different aesthetic designs can induce emotions and that these emotions affect users’ performance and cognitive process (Harp & Mayer, 1997; Mayer & Moreno, 1998; North & Hargreaves, 1999; Szabo & Kanuka, 1998; Tractinsky, Katz, & Ikar, 2000; Wolfson & Case, 2000). In addition, users’ positive perceptions about multimedia programs and learning suggest that positive emotions were produced by the different design of multimedia elements such as visual design principles, design layout, color, and sound (Tractinsky et al. 2000; Wolfson & Case, 2000). Lidwell, Holden, and Butler (2003) suggested 28 design principles that improve the appeal of design on a visceral level. These principles can be used when designing a multimedia learning environment. However, most of the principles are subjective and require a designer’s artistic sense, and it is difficult to simply apply these principles and expect a direct effect of positive emotions.

Our approach to induce positive emotion in multimedia learning therefore uses manipulations of the design of the environment that (1) do not add significant amounts of new information to the material, and (2) use established effects that have been empirically validated in their impact on learners’ positive emotions. These effects include the use of specific color combinations, anthropomorphism, and the baby face bias. Because this study does not investigate a specific mechanism of inducing positive emotions through the design of the learning materials, we refer to the combined application of all three visual design effects as positive emotional design.

**Color combination:** Various studies showed that people’s feelings are affected by colors, and colors can generate positive feelings and arousals of emotions such as pleasure and excitement (e.g., Berlyne 1970; Tucker, 1987). Red, warm colors elicit greater feelings of arousal than blue, cold colors (Bellizzi & Hite, 1992; Wolfson & Case, 2000). Results from research on advertising indicated that higher levels of chroma (saturation) and value (degree of darkness or lightness of the color) influence feelings of excitement and relaxation and these feelings, in turn, create positive attitude toward the brand (Gorn, Chattopadhyay, Yi, & Dahl, 1997; Thompson, Palacios, & Varela, 1992). Therefore, we used saturated and analogous bright warm color combinations for the entire screen design to make the positive emotional design treatment visually more appealing and aesthetically pleasing.

**Anthropomorphism:** Anthropomorphism is the attribution of uniquely human characteristics and qualities to nonhuman beings, inanimate objects, or natural or supernatural phenomena (Disalvo & Gemperle, 2007; Reeves, & Nass, 1996). Characters of anthropomorphic forms were used for some of the animated elements in the positive emotional design content. For example, facial expressions were added to the images of body cells and virus in presenting the concept of immunization. Anthropomorphic computer interfaces have been found to better attract users’ attention and engaging them in active tasks than non-anthropomorphic interfaces (Dehn & van Mulken, 2000), and animated characters were found to
be useful to retain learners’ attention and maintain engagement with the learning material (Hongpaisanwiwat & Lewis, 2003).

Baby-face bias: Illustrations and characters in the positive design material were designed as baby-face-like characters to induce baby-face bias. According to this effect (Lorenz & Generale, 1950), people or things with round features, large eyes, small noses, short chins are perceived as baby-like, and they induce baby-like personality attributes such as innocence, honesty, and helplessness, which induce positive affect in the learner.

In the present study we therefore aim to investigate whether positive emotions in multimedia learning environments facilitate or suppress cognitive processes and, as a result, learning. In particular, we are interested in the questions of how the internal induction of positive emotions (induction during learning, through the positive emotional design of learning materials) would affect learning outcomes, cognitive load, and motivation compared to an external induction of positive emotions (induction before a learning task, through a mood induction procedure). We were also interested in learners’ perception of their learning achievement and level of satisfaction with their learning experience.

Method

Participants and Design

The participants were 118 students who were enrolled at a large private university in the northeastern U.S. There were 49 male and 79 female participants, and all of them were over 18 years old ($M = 24.9, SD = 6.4$ yrs.). Each subject was compensated $10 for their participation. Subjects were randomly assigned to one of four treatment conditions, which were created by two design factors with two levels each. These factors were the external induction of positive emotions by means of a self-referencing Mood Induction procedure (positive (PE) or neutral (NE) emotions), and the internal induction of positive emotions by means of the Emotional Design of the learning materials (positive (PD) or neutral (ND) design). As a result, the control group (NEND group) received the neutral mood induction procedure and the material with neutral aesthetic design. The PEPD group received the positive mood induction procedure and material with positive emotional design. The PEND group received the positive mood induction procedure and the material with neutral design. The NEPD group received a neutral mood procedure and the material with positive emotional design.

Materials and Apparatus

Mood induction Procedure. To induce a positive or a neutral mood in the participants, a self-referencing mood induction procedure developed by Seibert and Ellis (1991a) was used. This procedure was specifically designed for use in laboratory settings and has been successfully used for mood induction.
in prior research on emotion and cognition with college students (Seibert & Ellis, 1991b). Of the three mood states the procedure can be used to induce, which are happy, sad, and neutral (control), the present study used only the happy and the neutral mood induction procedures. Each procedure involves reading 25 statements in a predetermined sequence; the program provided tones in 10-second intervals as signal when to advance to the next statement. In the neutral mood induction procedure, participants were instructed to read each statement to themselves and then read it out loud, and to advance to the next statement when they would hear a tone. Sample items from the neutral mood induction procedure are “There are sixty minutes in one hour.” and “Apples are harvested in the Fall.” In the positive mood induction procedure, participants were instructed to read each statement to themselves and then read it out loud. They were told that these statements represented a mood state and asked to feel and experience each statement as if it applied to them. They were instructed to advance to the next statement when they would hear a tone. Sample items from the happy mood induction procedure are “It doesn’t get any better than this.” and “It’s great to be alive!” Each of these two procedures was presented on a computer screen using a computer program developed in Flash (Adobe, 2006).

**Design of learning material.** A computer-based lesson covering the topic “How immunization works” was used as multimedia learning material. The first author developed this seven-minute program using Flash animation and HTML. Three instructional design professionals reviewed the content and instructional design of the materials. To manipulate affect, there were two different versions of design; the neutral emotional design was developed in monochromatic gray-scale, the positive emotional design was revised a revised version of the neutral design that applied established effects to induce positive emotions without changing the learning content of the materials (Figure 1):

![Figure 1](image)

*Figure 1. Screen shots of multimedia learning materials: Neutral Design (left) and Positive Design (right)*

We utilized three established effects for the variations in the visual design of the learning materials with positive emotional design compared to those with neutral design; color combination,
anthropomorphism, and baby-face bias. These principles were chosen because their emotional impact had been established in previous empirical research, and because they allow for a revision of a neutral interface that does not add any new learning content that would confound the results.

To make sure that changes to the visual design only affected aesthetic aspects, as well as to provide context-relevant seductive augmentation, the positive and the neutral design materials both had the same amount of learning content, user control options, and duration, and applied the same multimedia learning design principles (Mayer, 2001).

Measures
As a manipulation check of mood induction, the Positive Affect Scale (PAS) from the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1998) was used. The PAS asks respondents to indicate the degree to which they experience 10 different feelings related to positive affect, using a 5-point Likert-type scale ranging from 1 (very slightly or not at all) to 5 (very much) (coefficient alpha = .84). The total score for each participant was obtained by adding the 10 responses. The subscales have a high internal consistency (coefficient alpha = .89 for PA, .85 for NA) and are independent of one another when used to assess current, past, or general mood (Crawford & Henry, 2004).

Prior knowledge was assessed using a 7-item self-report checklist in which learners indicated their level of knowledge of the topic of the learning material, immunization. Participants received one point for each item that they reported, which span from “I can explain what antibodies are” to “I can explain what phagocytes are.” The total score for each participant was obtained by adding points from all 7 items.

To assess the learning outcome (performance) of the multimedia instruction, comprehension and transfer tests were administered. The comprehension test (coefficient alpha = .74) had 15 multiple-choice questions (e.g., “What is the role of phagocytes?”). Participants received one point for each question they answered correctly. The transfer test had four questions (e.g., “HIV, Human Immunodeficiency Virus, destroys T cells in immune system. Explain the consequences of this infection by describing the role of T cells in the process of immune system”). Participants received one point for each acceptable answer on each of the four problem-solving transfer sheets and the total score on each of the tests was obtained by adding points received for the individual items on the test.

To measure the cognitive load experienced by learners, participants completed a 9-point Likert style Cognitive Load Subjective Experience Questionnaire targeting invested mental effort (Paas, 1992) and a 7-point Likert style survey on their perceptions of task difficulty (Kalyuga, Chandler, & Sweller, 2000).
One 7-point Likert style question was used to measure users’ *satisfaction with their learning experience* of using the computer-based multimedia lesson. In addition, one 7-point Likert style question was asked to measure users’ *perception about their learning achievement*.

Learner’s *motivation* was measured using a self-report instrument consisting of an 8-item questionnaire with 7-point Likert style items developed by Isen and Reeve (2006) for measuring intrinsic motivation. Participants were asked to rate how interesting and enjoyable they found the experience (1 = strongly disagree, 7 = strongly agree). One point was assigned for each item, and each participant’s total score, obtained by adding responses from the 8 items, was used for the data analysis.

**Procedure**

The entire procedure, including the learning material and responses to the questionnaires, was administered through a computer system. The questionnaires were built in Survey Monkey (Finely, 2007), a web-based survey program, and linked with other materials in the order of the study procedure. Each participant was individually tested in a laboratory setting. Participants were randomly assigned to one of the four groups, and each participant worked in an individual session for about one hour.

After receiving a brief overview of the study procedure, each participant was seated in front of a computer. The participants received an introduction to the computer-based procedures and were asked to follow the instruction on the screen. After spending approximately 5 minutes completing the background questionnaires soliciting demographic information, twenty-five statements of either the positive or the neutral mood induction were displayed in ten-second intervals on an individual computer monitor. Participants were instructed to read each of the statements to themselves, and then read the statements aloud. This procedure lasted for approximately six minutes. To check whether the mood induction procedure affected participants’ emotions, the participants completed the first positive affect schedule (PAS). Next, the multimedia instruction with either neutral or positive design of the material was presented to the participants on the computer. They were told that they would be tested on the content of the material after the treatment. Participants were instructed to study the learning material for 15 minutes. After completing their learning task, participants were given approximately 25 minutes to complete the questionnaires of mental effort and perceived task difficulty, the second PAS, and self-report measure of intrinsic motivation, learning performance (comprehension and transfer tests), perception of achievement, and satisfaction with their learning experience. Participants were then thanked and excused. During the entire procedure, we followed American Psychological Association guidelines for the ethical treatment of human participants.
Results

The aim of the present study was to investigate whether positive emotions in multimedia learning environments facilitated or suppressed cognitive processing, and whether such emotions can be effectively induced using materials designed following Emotional Design principles. We used as controls groups in which positive and neutral emotions were induced using an established procedure of Mood Induction.

In analyzing the data obtained from this research, we first conducted a manipulation check to verify that the mood induction procedure had the desired effect of inducing positive v. neutral emotions. To answer our research questions, we then compared the level of change of emotions as result of the treatment. We next analyzed learning outcomes and experienced cognitive load for the four treatment groups. Finally, we compared the results for motivation, satisfaction with the learning experience, and perception of achievement of the treatment groups.

Manipulation Check of mood induction

Table 1 shows the descriptive statistics for the first PAS (after mood induction procedure) and the second PAS (after the treatment) for the four groups.

Table 1. Means, standard deviation, and number of participants for first and second PAS for the four treatment groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>1st PAS scores</th>
<th>2nd PAS scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>PEPD</td>
<td>34.1</td>
<td>9.2</td>
</tr>
<tr>
<td>PEND</td>
<td>36.7</td>
<td>8.7</td>
</tr>
<tr>
<td>NEPD</td>
<td>26.9</td>
<td>6.9</td>
</tr>
<tr>
<td>NEND</td>
<td>22.8</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Note. NEND–neutral mood induction procedure and neutral emotional design of material; PEPD–positive mood induction procedure and positive emotional design of material; PEND–positive mood induction procedure and neutral emotional design of material; NEPD–neutral mood procedure and positive emotional design of material.

Emotional State Before The Learning Treatment. An indication of a successful mood induction would be a significantly more positive emotional state of learners in the Positive Emotion groups (PEND and PEPD) compared to learners in the Neutral Emotion groups (NEND and NEPD). An Independent Samples t-test on the scores of 1st PAS test by Mood Induction condition (neutral, positive) revealed that
after the mood induction, the Positive Emotion groups ($M=35.3; SD=9.0$) rated their emotions significantly more positively than the Neutral Emotion groups ($M=24.9; SD=7.8$) at $t(116) = 6.637$, $p < .0001$, Cohen’s $d = 1.24$. This suggests that the mood induction was successful, and the intended neutral vs. positive emotional states were induced before the learning treatment.

**Change of Positive Emotions During The Learning Treatment.** An analysis of variance with repeated measures (RM-ANOVA) with treatment as between-subjects factor and PAS scores on the 1st and 2nd PAS tests as repeated measures variable indicated that the PAS scores of two groups changed significantly over the course of the treatment, see Figure 2. These two groups were PEND (Positive Emotions & Neutral Design group), $F(1, 28) = 4.981$, $p < .05$, partial eta squared $\eta^2 = .151$, for which positive emotions decreased significantly, and NEPD (Neutral Emotions & Positive Design group), $F(1, 28) = 6.733$, $p < .05$, $\eta^2 = .194$, for which positive emotions increased significantly (see Table 1 for descriptives).

![Figure 2](image)

**Figure 2.** PAS scores by treatment conditions before learning (1st PAS) and after the learning (2nd PAS)

**Emotional State After The Learning Treatment.** An analysis of variance (ANOVA) on the 2nd PAS score with treatment as a between-subjects factor revealed significant differences in positive emotion scores between the treatment groups; $F(3, 114) = 6.77$, $p < .001$, $\eta^2 = .151$. Post-hoc tests (Tukey HSD) revealed significant differences at the .05 level between the group NEND and the three other groups–PEPD ($p < .01$, Cohen’s $d = 0.95$), PEND ($p < .001$, $d = 1.21$), and NEPD ($p < .05$, $d = 0.79$). These
findings show that, at the end of the learning process, groups PEPD, PEND and NEPD had more positive emotions than the control group NEND, which stayed in a neutral emotional state.

These results indicate that the positive emotions induced externally, before the learning task, tended to decrease during the learning when the emotional design was neutral. However, the internal induction of positive emotion, through the positive emotional design of the learning material, helped maintain the positive emotions, and even increased the positive emotions during learning for those learners who had neutral emotions at the beginning of the learning task. These findings support our hypothesis that positive emotions can be induced through the learning material by applying emotional design principles.

Learning Outcomes

We were interested in how the internal induction of positive emotions (induction during learning, through the positive emotional design of learning materials) would affect learning outcomes compared to an external induction of positive emotions (induction before a learning task, through a mood induction procedure).

We first determined whether there were differences in prior knowledge among the four treatment groups. A oneway ANOVA with prior knowledge as dependent measure and treatment as factor did not reveal statistically significant differences, $F(1, 114) = 1.89$, ns. Prior knowledge was therefore not included in further analyses.

Comprehension. Means and standard deviations of the comprehension scores of the four treatment groups are reported in Table 2. In order to determine the effect of the two different manipulations of emotions on learners’ comprehension of the multimedia materials, we computed a 2 x 2 ANOVA with Emotional Design (neutral, positive) and Mood Induction (neutral, positive) as between-subject factors and comprehension test as dependent measure.
The analysis revealed a significant main effect for Emotional Design, $F(3, 114) = 11.57, MSE = 90.58, p < 0.001, \eta^2 = .092$. No main effect was found for Mood Induction ($F(3, 114) = 2.14, \text{ns.}$), and there was no interaction effect for the two factors ($F(3, 114) = .57, \text{ns.}$), see Figure 3. As predicted, learners whose positive emotional state was induced internally, through the emotional design of the learning materials, performed better on comprehension test than controls (neutral design, $M = 10.61, SD = 2.88$; positive design, $M = 12.39, SD = 2.74; d = .63$), but did not reveal the same finding for the external induction of positive emotions through the mood induction procedure (neutral induction, $M = 11.12, SD = 2.20$; positive induction, $M = 11.92, SD = 2.64$).

Table 2. Mean scores and standard deviations for each group on the comprehension test and transfer test.

<table>
<thead>
<tr>
<th></th>
<th>NEND (controls)</th>
<th>PEPD</th>
<th>PEND</th>
<th>NEPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td>10.4 (3.0)</td>
<td>12.9 (1.9)</td>
<td>10.8 (2.9)</td>
<td>11.8 (3.4)</td>
</tr>
<tr>
<td>Transfer</td>
<td>7.9 (4.9)</td>
<td>14.5 (5.3)</td>
<td>11.7 (5.4)</td>
<td>11.7 (4.6)</td>
</tr>
</tbody>
</table>

transfer. Means and standard deviations of the transfer scores of the four treatment groups are reported in Table 2. In order to determine the effect of the two different manipulations of emotions on learners’ transfer of the multimedia materials, we computed a $2 \times 2$ ANOVA with Emotional Design (neutral, positive) and Mood Induction (neutral, positive) as between-subject factors and transfer test as
dependent measure. The analysis revealed significant main effects for the external Mood Induction, \( F(3, 114) = 12.25, MSE = 314.80, p < .01, \eta^2 = .10 \), and for the internal Emotional Design, \( F(3, 114) = 12.51, MSE = 321.47, p < .01, \eta^2 = .10 \). As predicted, learners whose positive emotional state was induced externally, through the mood induction procedure, performed better on comprehension test than controls (neutral induction, \( M = 9.84, SD = 5.08 \); positive induction, \( M = 13.15, SD = 5.50; d = .62 \)). Likewise, learners whose positive emotional state was induced internally, through the design of the learning materials, performed better on comprehension test than controls (neutral design, \( M = 9.82, SD = 5.46 \); positive design, \( M = 13.16, SD = 5.13; d = .63 \)). There was no interaction effect for the two factors (\( F(3, 114) = .31, \text{ns.} \)), see Figure 4. These results show that both internal and external induction of positive emotions increased learners’ performance on the transfer test.

In summary, these findings show that the internal induction of positive emotions through Emotional Design of the materials was able to increase comprehension and transfer, whereas the external induction of positive emotions through a mood induction procedure enhanced transfer but not comprehension.

**Cognitive Load**

We measured two different types of cognitive load, invested mental effort (germane load) and perceived difficulty of the learning task (extraneous load). Means and standard deviations of these variables for the four treatment groups are reported in Table 3. For each of these measures, we computed a 2x2 ANOVA.
with Emotional Design (neutral, positive) and Mood Induction (neutral, positive) as between-subject factors.

The ANOVA computed on mental effort scores revealed a main effect for the external Mood Induction, $F(3, 114) = 7.52, MSE = 22.85, p < .01, \eta^2 = .062$. Learners who received a positive Mood Induction reported a higher amount of invested mental effort ($M = 6.49, SD = 1.71$) than learners who received a neutral Mood Induction ($M = 5.61, SD = 1.75; d = .51$). There was no main effect for Emotional Design (neutral design: $M = 6.07, SD = 1.98$; positive design: $M = 6.07, SD = 1.58$), nor an interaction effect of the two factors.

**Table 3.** Mean scores and standard deviations for each group on mental effort and perceived task difficulty.

<table>
<thead>
<tr>
<th></th>
<th>NEND (controls)</th>
<th>PEPD</th>
<th>PEND</th>
<th>NEPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Effort</td>
<td>5.6 (1.9)</td>
<td>6.4 (1.5)</td>
<td>6.6 (1.9)</td>
<td>5.7 (1.6)</td>
</tr>
<tr>
<td>Difficulty</td>
<td>3.4 (1.2)</td>
<td>3.0 (1.0)</td>
<td>3.2 (1.3)</td>
<td>3.0 (0.7)</td>
</tr>
</tbody>
</table>

The ANOVA computed on task difficulty scores revealed a marginally significant main effect for Emotional Design, $F(3, 114) = 3.62, MSE = 3.95, p = .06, \eta^2 = .031$. Learner receiving the internal induction of positive emotions through Emotional Design rated the difficulty of the learning material as lower ($M = 2.95, SD = .84$) than learners in the neutral emotional design condition ($M = 3.32, SD = 1.21; d = .36$). There was no main effect for Mood Induction (neutral induction: $M = 3.19, SD = .97$; positive induction: $M = 3.07, SD = 1.12$), nor an interaction effect of the two factors.

In summary, positive emotions induced before the multimedia learning task through Mood Induction significantly increased the amount of mental effort learners invested during learning. Positive emotions induced during the learning task through Emotional Design, on the other hand, reduced the perceived difficulty of the learning task.

*Learners’ Motivation, perception of learning achievement, and satisfaction with their learning experience*

Means and standard deviations of scores for motivation, learners’ perception of their learning experience, and learners’ satisfaction for the four treatment groups are reported in Table 4. For each of these measures, we computed a 2x 2 ANOVA with Emotional Design (neutral, positive) and Mood Induction (neutral, positive) as between-subject factors.

The ANOVA computed on the satisfaction scores revealed a significant main effect for Mood Induction, $F(3, 114) = 6.56, MSE = 11.58, p < .05, \eta^2 = .054$. Learners receiving the positive Mood
Induction procedure reported a higher satisfaction with their learning experience ($M = 5.34, SD = 1.25$) than learners receiving the neutral Mood Induction ($M = 4.72, SD = 1.42; d = .46$). No differences were found for Emotional Design (neutral: $M = 4.84, SD = 1.31$; positive: $M = 5.23, SD = 1.41$), and there was no interaction effect for the two factors.

Table 4. Mean scores and standard deviations for each group on satisfaction, perception, and motivation.

<table>
<thead>
<tr>
<th></th>
<th>NEND (controls)</th>
<th>PEPD</th>
<th>PEND</th>
<th>NEPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction</td>
<td>4.4 (1.3)</td>
<td>5.4 (1.3)</td>
<td>5.3 (1.2)</td>
<td>5.0 (1.5)</td>
</tr>
<tr>
<td>Perception</td>
<td>3.8 (1.4)</td>
<td>5.1 (1.5)</td>
<td>4.5 (1.3)</td>
<td>4.5 (1.4)</td>
</tr>
<tr>
<td>Motivation</td>
<td>28.9 (10.0)</td>
<td>36.8 (8.4)</td>
<td>35.0 (9.2)</td>
<td>35.0 (9.2)</td>
</tr>
</tbody>
</table>

The ANOVA computed on learners’ perception of learning achievement scores revealed a significant main effect for Mood Induction, $F(3, 114) = 7.06, MSE = 13.32, p < .01, \eta^2 = .058,$ and for Emotional Design, $F(3, 114) = 5.69, MSE = 10.73, p < .05, \eta^2 = .048.$ Learners receiving the positive Mood Induction procedure reported a higher perception of their learning achievement ($M = 4.80, SD = 1.38$) than learners receiving the neutral Mood Induction ($M = 4.12, SD = 1.40; d = .46$). Likewise, learners whose positive emotional state was induced internally, through the design of the learning materials, reported a higher perception of their learning achievement than controls (neutral design, $M = 4.84, SD = 1.31$; positive design, $M = 5.23, SD = 1.41; d = .29$). These results indicate that both methods of inducing positive emotions increased learners’ perception of their learning achievement.

The ANOVA computed on the motivation scores revealed a significant main effect for the external Mood Induction, $F(1, 114) = 6.54, MSE = 554.72, p < .05, \eta^2 = .054,$ and a significant main effect for Emotional Design, $F(1, 114) = 4.20, MSE = 356.30, p < .05, \eta^2 = .036.$ Learners receiving the positive Mood Induction procedure reported a higher motivation ($M = 36.34, SD = 8.75$) than learners receiving the neutral Mood Induction ($M = 32.04, SD = 10.01; d = .46$). Likewise, learners whose positive emotional state was induced internally, through the design of the learning materials, reported a higher motivation than controls (neutral design, $M = 32.47, SD = 10.17$; positive design, $M = 35.93, SD = 8.76; d = .36$). This result indicates that both internal and external methods of inducing positive emotions increased intrinsic motivation during learning.

In summary, learners’ satisfaction with the material was significantly increased only by positive emotions induced before the multimedia learning task through Mood Induction. Learners’ motivation and
their perception of their learning achievement was significantly increased by both positive Mood Induction and positive Emotional Design.

**Discussion**

The primary purpose of this study was to investigate whether positive emotions in multimedia-based learning would facilitate or suppress cognitive processes and learning. We were further interested whether these positive emotions could be induced by applying emotional design principles to the learning materials. For this investigation, positive emotions were therefore experimentally induced either internally, during the learning by the emotional design of the learning materials (positive or neutral design), or externally, by means of self-referencing mood induction procedure administered before a multimedia learning treatment (positive or neutral emotions). We examined the effects of positive emotions on learning performance, cognitive load, and other affective experiences.

**Emotional States during Learning**

Emotions are defined as lasting for relatively short periods of time - minutes or hours - and they change behavior over a relatively short term, because they are responsive to the immediate events (Desmet, 2002; Ekman, 1994; Norman, 2004). As expected, our study found that the degree of positive emotions induced externally, before the learning through the mood induction procedure, significantly decreased toward the end of the learning. In contrast, the internal induction of positive emotions though the design of the learning materials maintained the positive emotional state until the end of the learning task.

Our data show that positive emotions can be induced through the quality of the design of the learning material. Several studies have suggested that positive emotions were produced by different designs of multimedia elements such as visual design principles, design layout, color, and sound (e.g., Tractinsky et al. 2000; Wolfson & Case, 2000). This study utilized three established effects for the visual design of the learning materials that aimed to induce positive emotions, namely using saturated and analogous bright warm color combinations, using characters of anthropomorphic forms, and using round, baby-like features (baby-face bias). These principles were chosen because their emotional impact had been established in previous empirical research, and because they can be implemented in the visual interface of most learning materials without adding any new learning content that would confound the results.

The positive emotional design that incorporated these principles maintained the positive emotional state and even increased positive emotions of those learners who had a neutral emotional state in the beginning of the learning process. At the end of the learning task, learners in all three treatment
groups were in a positive emotional state, and only the learners in the control group, who received the neutral mood induction and neutral design of the materials, remained in a neutral emotional state.

**Learning Outcomes**

Results showed that learners who studied the materials that were designed to induce positive emotions performed better on the comprehension test than learners who received the neutral design. In addition, both methods of inducing positive emotions externally, before learning, and internally, using materials designed to induce positive emotions, increased participants’ performance on the transfer test. These results support the facilitation hypothesis that a positive emotional state serves as an effective retrieval cue for other positive materials in memory (Isen et al., 1978; 1984). Especially the results of the transfer test support the idea that positive emotions promote cognitive organization and creativity. According to the research by Isen and her colleagues, positive affect provides retrieval cues to the positive material and influences cognitive organization by altering the context in which cognitive activity takes place. Cognitive process may be more flexible as a function of positive affect, which may also result in greater creativity and improved problem-solving ability (Isen & Daubman, 1984; Isen et al., 1985; 1987; 1991).

Our research offers a method to overcome the dilemma that although positive emotions can facilitate learning, several methods of inducing these positive emotions are implicated as suppressing learning. Cognitive load research suggests that adding any information that is not directly related to the learning task would increase cognitive load and might hinder learning (Sweller, 1988; 1994). The related Seductive Detail effect posits, for example, that adding seductive details aimed at increasing learners’ emotional interest would distract from the educational content (Garner et al., 1989; Harp & Mayer, 1997). Our data show that the method of inducting positive emotions used in this increased learners’ comprehension and knowledge transfer rather than hurt learning. In our study, the design was enhanced by improving the aesthetic design of key elements of the content, not by adding seductive details, but by improving the emotional design of the materials that increased learners’ situational interest.

**Cognitive Load**

Our results also showed that positive emotions induced externally, before the learning task, resulted in a higher reported mental effort investment (germane cognitive load) by learners during the learning task. In addition, we found that positive emotions induced internally, through a positive emotional design, resulted in a lower reported task difficulty (extraneous cognitive load) than a neutral emotional design. This is inconsistent with the suppression hypothesis of positive emotions on cognitive process, which would have predicted increased extraneous load for the positive emotional design. Seibert and Ellis (1991) suggest that a positive mood may increase the load on working memory because being happy
tends to increase the incidence of mood-related thoughts that interrupt processing on a given cognitive task. We did not find support for this hypothesis, nor for the possibility that the external method of inducing positive emotions before the learning task through a self-referencing mood induction procedure (Seibert & Ellis, 1991a), which involved the introduction of information that were not directly related to the learning content, would result in the increased perceived task difficulty.

Our findings show that our internal method of inducting positive emotions was able to do so without generating additional extraneous load, in fact, we found that learners reported lower extraneous load in the positive emotional design condition compared to the neutral condition. This is in contrast to the prediction by cognitive load theory that emotional design elements and seductive details would impose extraneous cognitive load. This result suggests that our goal to enhance the emotional design of the material without adding any information, whether relevant or irrelevant, that would have required additional cognitive load to process, was successful.

**Motivation, Satisfaction, and Perception**

Our result also showed that both externally and internally induced positive emotions increased the intrinsic motivation during the learning. This is consistent with the previous studies that had found that positive affect promotes intrinsic motivation (Erez & Isen, 2002; Isen & Reeve, 2005). As expected, positive emotions induced before learning affected the learning process by influencing the cognitive process involved in motivation and facilitated intrinsic motivation.

It is interesting to note that the emotional design of the learning material increased the motivation without hurting the learning performance. This result is consistent with Park’s (2006) finding that seductive graphics positively affected students’ level of interest without hurting the learning performance.

This study also found that the positive emotions induced before the learning increased the satisfaction toward the same learning material and experience. This result is consistent with several previous study that found that positive emotions are direct or indirect factors in changing people’s affective experiences such as attitude, judgment, evaluation, and satisfaction (Isen, Shalker, Clark, & Karp, 1978; Isen & Patrick, 1983; Petty et al., 1993; Weiss et al., 1999). The result regarding of learners’ perception of their learning achievement supports this hypothesis as well. Both external and internal methods of inducing positive emotions increased learners’ perceptions of the learning outcome.

**Limitations**

As is the case for all empirical studies, the protocol used in the present research imposes certain limitations on the generalizability of our findings. Among the limiting variables are the population used for this research, which included students at a highly selective university, the subject matter used, which
focused on science learning, and the type of learning materials used, which consisted of a computer-based multimedia program with limited interactivity. Further research needs to investigate whether our findings can be applied to other populations, subject matter areas, and types of learning materials. In this research we also chose to use a combination of three established design principles to induce positive emotions through the learning materials. Due to the design of the research we cannot make claims as to the individual contributions of each of these methods, which will be subject of our future research.

Conclusion

The results of this study showed that positive emotions facilitate cognitive processes and other affective experiences in a multimedia-based learning environment and enhance learning. This research has important theoretical as well as practical implications.

On the theoretical side, we were able to show that positive emotions do not only affect cognition, as found in previous research, but that they also increase learning outcomes. The suppression hypothesis of positive emotions suggests that, because mood can take extra-task processing or task-irrelevant processing in working memory, it will have a negative effect on reasoning and performance (Ellis & Ashbrook, 1987; Oaksford et al., 1996; Seibert & Ellis, 1991a). In this study, however, the emotional design method we used did not increase the extraneous cognitive load induced by the learning materials and did not have any negative effect on learning performance. On the contrary, the result of this study is consistent with previous studies supporting the facilitation hypothesis of positive emotions, which suggests that positive emotions help long-term memory and retrieval and facilitate working memory process including creative problem-solving skills (Erez & Isen, 2002; Isen & Patrick, 1983; Isen et al. 1987; 1991; Petty et al., 1993, Weiss et al., 1999). The study results also suggest that positive emotions increase learners’ germane cognitive load, i.e., the amount of mental effort they invest into the learning process, when the emotions were induced externally.

Another important theoretical implication of our research is that it showed that the emotional design of the learning environments can provide a more effective and longer lasting positive emotional state than mood induction procedures administered before the treatment (Seibert & Ellis, 1991b). Previous studies have used short tasks right after the emotional state had been induced. Compared to those tasks, multimedia learning materials used in this research is relatively long and complex, making the effect of positive emotions we found on learning even more significant.

On the practical side, this research provides empirical support for the need to consider emotional design effects in multimedia learning environments. Learners studying materials with the improved emotional design had better comprehensive and knowledge transfer, a more positive perception of and
better motivation toward learning. The study provides instructional designers with methods to improve the emotional design of multimedia learning materials that can induce positive emotions without adding additional information that would distract learners from the educational content, and that can therefore enhance learning outcomes.

In summary, the results of this study provide initial evidence that positive emotions can facilitate cognitive processes in the context of learning and suggests that positive emotions should be considered an important factor that should be incorporated into instructional design.

References


