I feel, therefore I learn – Effectiveness of affect induction interventions and possible covariates on learning outcomes

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Zusammenfassung

Affektiven Zuständen im Lern- und Leistungskontext wird ein wesentlicher Einfluss auf den Lernprozess zugesprochen. Dabei wirken diese sowohl direkt auf die Lernleistung als auch indirekt vermittelt über beispielsweise motivationale Prozesse. Dennoch handelt es sich bei diesem Forschungsgebiet um ein noch relativ junges Feld. Während bis zur Jahrtausendwende der Fokus der Forschung vor allem auf der Untersuchung von Prüfungsangst und die mit dem Leistungsmotiv einhergehenden Emotionen Scham und Stolz bzw. Trait-Motivation lag, rücken seither affektive Zustände wie (Lern-)Freude, Verwirrung, Frustration oder Flow-Erleben in den Mittelpunkt. Positive aktivierende Affekte stehen dabei oft im Zusammenhang mit erhöhter Gedächtnisleistung und kreativer Problemlösefähigkeit. Negative aktivierende Affekte anderseits werden eher als lernhinderlich angesehen, da sie aufgabenirrelevantes Denken fördern. Während sich diese Zusammenhänge im Rahmen korrelativer Studien als relativ stabil erwiesen haben, sind kausale Beziehungen zwischen affektiven Zuständen und Lernleistung sowie Leistungsmotivation bislang noch eher selten untersucht. Darüber hinaus sind Studien, die sich mit lernrelevanten affektiven Zuständen Lern- und Leistungssituationen von vergleichsweise kurzer Dauer und außerhalb des Klassenraums beschäftigen, relativ rar. Die wenigen experimentellen Studien in diesem Bereich formen zudem eine eher heterogene Befundlage.

Diese Arbeit hat daher zum Ziel, die Auswirkungen von positiven und negativen aktivierenden affektiven Zuständen beim Lernen mit Hypermedien genauer zu betrachten und mögliche moderierende Einflussfaktoren zu erkennen. Dabei wurden drei experimentelle empirische Studien mit Universitätsstudierenden durchgeführt.

In *Experiment 1* wurde Studierenden ($N = 57$) zufällig positiver oder negativer aktivierender Affekt mithilfe von kurzen Filmsequenzen induziert. Nach einer 20-minütigen Lernphase in einer hypertextbasierten multimedialen Lernumgebung zum Thema „Funktionelle Neuroanatomie“ wurden die Verständnis - und Transferleistungen der Studierenden gemessen. Im Vergleich zu einer Kontrollgruppe wurde dabei angenommen, dass sich positiver aktivierender Affekt vor dem Lernen positiv auf die Lernleistung auswirkt, während vor dem Lernen induzierter negativer aktivierender Affekt die entgegengesetzte Wirkung haben sollte. Es zeigte sich, dass die Induktion von negativem aktivierenden Affekt vor dem Lernen zu einer leichten Verschlechterung der Verständnisleistung führte. Diese Ergebnisse waren unabhängig von der Leistungsmotivation der Studierenden. Entgegen der Vermutungen zeigten Probanden, bei denen positiver aktivierender Affekt vor dem Lernen erzeugt wurde, jedoch keine Verbesserung der Lernleistung. Als mögliche Erklärungsursache hierfür wurde unter anderem angenommen, dass die Affektinduktion vor dem Lernen zwar erfolgreich war, diese Affekte jedoch nicht für die gesamte Dauer der Lernzeit anhielten.

Aufbauend auf diesen Befunden untersuchte *Experiment 2* den Einfluss von positivem aktivierenden Affekt auf das Lernen differenzierter. Es wurde angenommen, dass positiver aktivierender Affekt während des Lernens positive Auswirkungen auf die Lernleistung hat. Um den Affekt während der gesamten Lerndauer zu induzieren, verwendete Experiment 2 ein „emotional design“ Paradigma. Dabei wurden $N = 111$ Universitätsstudierende zufällig einer affektinduzierenden multimedialen Lernumgebung (Verwendung von warmen Farben und runden Formen) oder einem affektneutralen Gegenstück (Verwendung von Grautönen und eckigen Formen) zum Thema „Funktionelle Neuroanatomie“ zugeordnet. Nach einer Lernzeit von 20 Minuten wurden Verständnis- und Transferleistungen gemessen. Zusätzlich wurden vor und nach dem Lernen der positive Affekt und die Leistungszielorientierung als Maß für die Leistungsmotivation erhoben. Die Ergebnisse von Experiment 2 zeigen, dass die Affektinduktion nicht für alle Studierenden gleichermaßen wirkt. In der Untersuchung wurden komplexe Interaktionsmuster zwischen dem Treatment und positivem und negativem Affekt vor dem Lernen gefunden: Lernende, die vor dem Lernen stark positiv gestimmt waren, zeigten eine bessere Transferleistung, wenn sie in der affekt-erzeugenden Lernumgebung lernten. Berichteten die Lernenden dagegen hohe Ausprägungen von negativem Affekt vor dem Lernen, so sank ihre Verständnisleistung. Dieser Effekt trat allerdings nicht auf, wenn in der affekterzeugenden Lernumgebung gelernt wurde. Für Verständnislernen schützte das Treatment daher vor schlechterer Performanz durch stark ausgeprägten negativen aktivierenden Affekt vor dem Lernen. Entgegen der Erwartungen zeigte sich jedoch kein Einfluss des Treatments auf Leistungsziele.

Die Ergebnisse von Experiment 2 weisen darauf hin, dass die Induktion von positivem aktivierenden Affekt das Lernen positiv beeinflusst, wenn man die Affektausprägungen vor dem Lernen berücksichtigt. Um diese Interaktionseffekte zu bekräftigen, wurde in *Experiment 3* eine konzeptuelle Replikation des vorangegangenen Experiments durchgeführt. Dazu wurde das Studiendesign größtenteils beibehalten, jedoch die verwendeten Lernmaterialien und Lerntests verändert. Analog zu Experiment 2 lernten $N = 145$ Universitätsstudierende in Experiment 3 für 20 Minuten entweder in einer affekterzeugenden oder einer affektneutralen Lernumgebung zum Thema „Die eukaryotische Zelle“. Zu Stärkung des Treatments wurden in Experiment 3 neben warmen Farben und runden Formen auch anthropomorphe Designelemente zur

Induktion von positivem aktivierenden Affekt verwendet. Darüber hinaus wurde eine zusätzliche Messung des positiven und negativen Affektes in der Mitte der Lernzeit eingefügt, um die Veränderung des affektiven Erlebens während des Lernens differenzierter zu erfassen. Als Maße für die Lernleistung wurden erneut Verständnis und Transfer sowie die Gedächtnisleistung erhoben. Um den Einfluss potentieller konfundierender Variablen zu kontrollieren wurden zudem die generelle und aktuelle Leistungsmotivation, das Interesse sowie die Emotionsregulation gemessen. Entgegen der Erwartungen, konnte Experiment 3 die Interaktionseffekte aus Experiment 2 nicht bestätigen. Stattdessen zeigte sich ein signifikanter Einfluss des positiven aktivierenden Affektes vor dem Lernen auf die Transferleistung, unabhängig von der Gruppenzugehörigkeit des Lernenden. Dieser Effekt war unabhängig von den erhobenen Kontrollvariablen. Dennoch passen die Ergebnisse in das heterogene Befundmuster, welches sich durch die wenigen experimentellen Studien zu „emotional design" beim Lernen abzeichnet. Eine Klärung der Frage, ob sich die in Experiment 2 gefundenen Effekte als stabil erweisen, ist daher nicht endgültig möglich.

Obwohl die komplexen Interaktionsmuster aus Experiment 2 in Experiment 3 nicht repliziert werden konnten, erweitert die vorliegende Arbeit die wissenschaftliche Befundlage bezüglich der Rolle von affektiven Zuständen in konkreten Lernsituationen. Wie in zahlreichen früheren Publikationen fanden sich auch in den Studien, in denen positiver aktivierender Affekt direkt während des Lernens induziert wurde (Experimente 2 und 3), positive Korrelationen zwischen positivem Affekt und Lernleistung sowie Leistungsmotivation. Die Ergebnisse dieser Dissertation sind generell im Einklang mit anderen Publikationen, nach denen positiver Affekt beim Lernen positiv mit Lernleistung zusammenhängt, während negativer Affekt beim

Lernen die Leistung beeinträchtigen kann. Da viele dieser Studien die Lernleistung und den Affekt über einen längeren Zeitraum (z.B. Semester oder Schuljahre) betrachten, ist es umso erstaunlicher, dass ähnliche Ergebnisse unter Verwendung einer relativ kurzen experimentellen Manipulation gefunden werden konnten. Das experimentelle Vorgehen stellt daher eine der größten Stärken der vorliegenden Dissertation dar, auch wenn kritisch anzumerken ist, dass die ökologische Validität durch die Untersuchung im Labor im Vergleich zu Feldstudien eingeschränkt wird. Dennoch lassen die Ergebnisse dieser Arbeit darauf schließen, dass es zu komplexen Wechselwirkungen zwischen dem affektiven Zustand vor einer Lern- oder Leistungssituation und Maßnahmen zur Verbesserung des emotionalen Erlebens beim Lernen kommen kann. Diese Befunde geben demnach Hinweise auf die Mechanismen, die den Zusammenhängen von positiven und negativen Affekten und der Lernleistung zugrunde liegen.

Abstract

Affective states in the context of learning and achievement can influence the learning process essentially. The impact of affective states can be both directly on the learning performance and indirectly mediated via, for example, motivational processes. Nevertheless, research in the area is still relatively new. Up to the new millennium, the focus of research was especially on the investigation of test anxiety and emotions associated with the achievement motive such as shame and pride or trait motivation. Since then, newer studies also investigated affective states like (learning) joy, confusion, and frustration or flow experience. Therefore, positive activating affect is often associated with increased memory skills as well as advantages in creative problem solving. Negative activating affect on the other hand is regarded to impair learning outcomes because of promoting task-irrelevant thinking. While these relationships were found to be relatively stable in correlation studies, causal relationships between affective states and learning performance as well as achievement motivation have been examined rarely so far. In addition, there are still only a few studies dealing with learning relevant affective states in learning situations of relatively short durations outside the classroom context. Moreover, these few studies also form a rather heterogeneous picture on the role of affective states.

This dissertation aims to investigate the effects of positive and negative affective states in multimedia learning settings and to identify potential moderating factors. Therefore, three experimental empirical studies on university students were conducted.

In *Experiment 1*, $N = 57$ students were randomly allocated to either a positive or negative affect induction group. Affects were elicited using short film clips. After a 20-minute learning phase in a hypertext-based multimedia learning environment on

“functional neuroanatomy” the learners’ knowledge as well as transfer performance were measured. Compared to a control group, it was assumed that inducing positive activating affect should enhance learning performance. Eliciting negative activating affect on the other hand should impair learning performance. However, it was found that the induction of negative activating affect prior to the learning phase resulted in slight deteriorations in knowledge. These results were independent of the learners’ achievement motivation. Contrary to the assumptions, inducing positive activating affect before the learning phase did not improve learning performance. One possible explanation was that the affect induction procedure, despite successful, did not persist for the whole duration of the learning phase.

Based on these results, *Experiment 2* examined the effects of positive activating affect on learning outcomes in a more differentiated manner. It was assumed that positive activating affect that was induced directly during learning could have positive impacts on learning performance. To induce affective states during the entire duration of the learning phase, Experiment 2 used an emotional design paradigm. Therefore, $N = 111$ university students were randomly assigned to learn either in an affect inducing multimedia learning environment (use of warm colours and round shapes) or an affectively neutral counterpart (using shades of grey and angular shapes) on the same topic as in Experiment 1. Again, knowledge as well as transfer performance were measured after learning for 20 minutes. In addition, positive and negative affective states as well as achievement goal orientations as an indicator of achievement motivation were measured before and after learning. The results of Experiment 2 showed that the affect induction did not work equally for all participants. Instead, complex interaction patterns between the treatment and initial affective states were found. Specifically, learners with high levels of positive affect before learning showed better transfer performance when they learned in the affect inducing learning environment. Regarding knowledge, those participants who reported high levels of negative activating affect prior to the learning period performed worse. However, the effect on knowledge did not occur for those students learning in the affect inducing learning environment. For knowledge, the treatment therefore protected against poorer performance due to high levels of negative affective states. Contrary to expectations, there was no effect of the treatment on achievement goal orientations.

Results of Experiment 2 showed that the induction of positive activating affect influenced learning performance positively when taking into account affective states prior to the learning phase. In order to confirm these interaction effects, a conceptual replication of the previous experiment was conducted in *Experiment 3*. Experiment 3 largely retained the former study design, but changed the learning materials and tests used. Analogous to Experiment 2, $N = 145$ university students learning for 20 minutes in either an affect inducing or an affectively neutral multimedia learning environment on “eukaryotic cell”. To strengthen the treatment, Experiment 3 also used anthropomorphic design elements to induce affective states next to warm colours and round shapes. Moreover, in order to assess the change in affective states more exactly, an additional measurement of positive and negative affective states after half of the learning time was inserted. Knowledge and transfer were assessed again to measure learning performance. The learners’ memory skills were used as an additional learning outcome. To control the influence of potential confounding variables, the participants’ general and current achievement motivation as well as interest, and emotion regulation skills were measured. Contrary to the assumptions, Experiment 3 could not confirm the interaction effects of Experiment 2. Instead, there was a significant impact of positive activating affect prior to the learning phase on transfer, irrespective of the learners' group affiliation. This effect was further independent of the control variables that were measured. Nevertheless, the results of Experiment 3 fit into the picture of findings regarding "emotional design" in hypermedia learning settings. To date, the few publications that have used this approach propose heterogeneous results, even when using identical materials and procedures. Hence, the question of repeatability of the effects observed in Experiment 2 remains open.

Although the complex interaction patterns of Experiment 2 could not be replicated in Experiment 3, this work extends the scientific view on affective states in concrete learning situations. The experiments in which positive activating affect was induced directly during learning (Experiments 2 and 3), further showed positive correlations between positive activating affect and learning performance as well as achievement motivation. This is in line with numerous previous publications. Hence, the findings of this dissertation generally support other studies that have shown that positive activating affect can promote learning outcomes, while negative activating affect impairs learning performance. Since many of these studies consider learning performance as well as affective experiences over longer periods (for example, semesters or school years), it is even more surprising that similar results could be found using a relatively short experimental intervention. Therefore, the experimental procedure is one of the biggest strengths of this dissertation, although it has to be considered that the ecological validity may be impaired due to the laboratory study approach. However, the results also indicate complex interactions between treatments in order to improve affective experiences during learning and affective states prior to a learning or achievement situation. Accordingly, these findings give reference to the mechanisms that underlie the relationships between positive and negative affects and learning performance.

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1 Introduction

> Textbooks are open on the table, half-buried under a wild mix of printed scripts and handwritten notes. The four differently coloured highlighters have not been seen for some time. The student, who is sitting at the desk, is tearing his hair and staring with narrowed eyes at the text section spread before him. It is just the moment, when he does not understand a single phrase in that paragraph he has been reading for the last hour, that lets the student experience a mixture of frustration and boredom. He then decides to postpone the examination until next year. Suddenly, a change of scene: Another student is preparing for the same exam. After initial difficulties, to understand the complex learning material, she now manages to comprehend the material quite effortlessly. With a narrow smile and a slight sense of pride about her own performance, she finds it easy to capture the rest of the content. Coming to terms with the big picture of the topic, the student even enjoys her actions. The test is passed with top marks (adapted from Münchow, 2016, para. 1).

For most people who have ever been in an achievement situation, the feelings and thoughts above might look familiar. Who has not become confused or frustrated because of encountering initially incomprehensible learning content? Who has never felt pride after receiving praises for achieving academic objectives? Moreover, who has not yet made the experience of *eureka* and subsequent commitment to continue learning after finally overcoming a learning obstacle?

Yet, although affective reactions are well known to occur in achievement situations, scientific research neglected them for a long time. With the beginning of the cognitive revolution in the 1950s, research in experimental psychology was redefined from a behaviouristic into a cognitive way of thinking. Whereas scientists, especially in the US, had excluded mental processes from investigation, areas of research like memory, decision making or problem solving became more and more popular with this shift in thinking (see Miller, 2003 for a short review). Cognition was first defined by Neisser (1967) as “all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used" (p. 4). Later on, these approaches also influenced the field of educational research (Mayer, 1992). Accordingly, for a long time research in learning and instruction mainly concentrated on cognitive correlates of learning. In recent years, the role of affective states in the learning process has gained more and more attention. Several new studies indicate that experiencing different positive and negative affects before, while and after a specific achievement or learning situation can strongly influence learning outcomes. These outcomes encompass performance or levels of achievement motivation, as well as learning related cognitive and motivational processes such as self-regulation, the use of learning strategies, causal attributions, and beliefs in self-efficacy (for an overview, see Pekrun & Stephens, 2011).

Although the number of scientific publications on affect in academic situations has increased over the past 15 years, the causal relation of learning related affective states has rarely been examined. Consequently, particular research questions are only fragmentarily answered, as for instance, which affective states are beneficial for learning outcome and one's motivation to learn and how these states can be intentionally elicited in the learning situation. Furthermore, approaches to investigate the causal influence of positive affect in multimedia learning are still lacking. This is even more astonishing when considering that multimedia reception of content nowadays is virtually omnipresent, not only in the learning context. According to Mayer (2009), multimedia learning is thereby defined as "learning from words and pictures" (p. 43). Until now, there are only a handful of studies investigating the causal relationship of affective states on learning outcomes in multimedia learning. Consequently, there is still no coherent answer to the question how affective experiences impact learning outcomes and what may be potential influencing variables on these effects. Hence, the present work seeks to shed further light on this area of research by conducting three experimental studies, with each of them addressing several aspects of the role of affective states in the learning context. More particularly, the three experiments investigate how learning related affects can be induced and how these states affect learning performance and achievement motivation. Moreover, several possible additional variables are examined in order to test for potential moderation or confounding effects. In doing so, this work contributes in expanding the knowledge on some of the most fundamental questions in this research area.

This work is divided into four chapters with each of them containing several sections. The upcoming chapter 2 describes the theoretical background of this work. First, emotion and affect are described in general. Then, several theoretical assumptions on affective states are contrasted. Moreover, approaches to distinguish different emotional reactions are illustrated and operational definitions of the terms affect and emotion are derived. These concepts are then transferred into the learning context by introducing basic concepts of learning related affective states. Accordingly, theoretical approaches on the antecedents and consequences of these affects are illustrated. Furthermore, the influence of affective states on learning outcomes based on previous findings as well as the relationship between learning related affective states and achievement motivation are described. At the end of chapter 2, open questions are highlighted in more detail and hypotheses are derived. Chapter 3 covers this work's main part, that is, an experimental investigation of the influence of learning related affective states on learning outcomes. Therefore, three experiments are displayed comprehensively referring to their methods, results and the interpretation of their findings. Experiment 1 deals with the role of positive and negative affective states that are elicited prior to a complex learning task. Experiment 2 induces affective states directly during learning. Based on Experiments 1 and 2, Experiment 3 conceptually replicates the findings using slightly changed materials. The final chapter 4 summarizes the results of the empirical part of this dissertation. Furthermore, this chapter includes the conclusions and implications of this work as well as an outlook on future research.

2 Theoretical Background

This section illustrates the main theoretical conceptions that underlie the empirical part of this dissertation. First, there is a description of emotion theories and models in general. This work thereby uses the terms ‘affect’ and ‘emotion’ synonymously as far as possible subsuming all kind of affect-related phenomena[1]. Yet, as different researchers distinguish between the terms, conceptual distinctions are described in order to provide an operational definition of what is the key conception in this work. Further, theoretical models and explanations as well as empirical findings of this work’s key constructs emotions, affect, and motivation in the learning context are given. On this basis, a working model on the role of affective states in deep learning situations is derived. Furthermore, the role of affects in the learning context as well as the relationship between affect and achievement motivation is discussed. Finally, a description of open questions as well as this works aims and hypotheses are given.

2.1 Emotion & Affect

As early as 1884, William James provided a general definition of emotional respectively affective reactions by describing them as adaptive, behavioural and physiological reaction tendencies. James has thereby proposed that affective states are developed as consequences of physical changes. Accordingly, one feels sad because of the physical act of crying. However, there has been a great deal of criticism following James’ attempt to define emotional reactions (e.g., Wundt, 1891a,b; Dewey, 1894). A revised theory (James & Lange, 1922) was also rejected due to criticism from Walter Cannon (1927). Ever since, emotion theorists have sought to develop a generally

[1] Some of the theoretical approaches proposed by emotion theorists describe the terms inconsistently. Unless otherwise stated, this work uses the terms synonymously.

applicable definition of the constructs. Unfortunately, this aim has not yet been fulfilled, that is, there is still no commonly accepted definition of the main conceptions of affect, mood or emotion (e.g., Frijda, 1986; Izard, 2010). Consequently, various definitions of what emotional reactions truly are complicate the scientific discourse. Furthermore, there is a lack of conceptual clarification and delineation of terms like emotion, affect, mood, feeling, or temperament. As a result, these terms are sometimes used to distinguish between different affective states. Other authors in turn use these terms synonymously. In some cases, these inconsistencies in the terminology make it difficult to comprehend the preceding ideas in a specific study or to compare operationalization of affect-related variables between publications. Hence, it is useful (if not necessary) to provide a working definition of the key concepts of a particular study in order to avoid misconceptions.

2.1.1 Definition

There have been plenty of attempts to define the concept of affective phenomena. By systematically reviewing existing literature, Kleinginna and Kleinginna (1981) compiled a list of not less than 92(!) definitions and theoretical explanations of emotions. Definitions thereby extended from cognitive-behaviouristic to more psychological and up to even pragmatically inspired approaches. Thus, Skinner (1971) defined emotions as “excellent examples of the fictional causes to which we commonly attribute behavior” (p.160). Other approaches focus more on neurological, physiological or psychological components of affective reactions or try to integrate different aspects. Given the considerable amount of definitions, several researchers chose a rather pragmatic attempt to explain emotions. For example, Averill (1980) assumes that emotions are what people think they are. The content of more than 30 definitions of emotions were analysed by Izard (2010). Izard classified similar elements in the definitions into categories. Later on, the researchers who had provided the definitions in the first place were given the newfound categories and were asked to report back, whether these categories were part of their conceptualization of the term ‘emotion’. Due to the diversity of the responses, Izard argued that there is no way to integrate all of the aspects that can be used to describe emotional phenomena into one conceptualization. He therefore advised researchers to provide operational definitions of what they are investigating in a specific study. Frijda (1986) even suggested that a definition of what emotions are is always the result of the researcher’s scientific analyses. However, there are also similarities between different definitions. Izard (2010) found several distinct elements that were frequently reported as parts of an emotional reaction:

> Emotion consists of neural circuits (that are at least partially dedicated), response systems, and a feeling state/process that motivates and organizes cognition and action. Emotion also provides information to the person experiencing it, and may include antecedent cognitive appraisals and ongoing cognition including an interpretation of its feeling state, expressions or social-communicative signals, and may motivate approach or avoidant behavior, exercise control/regulation of responses, and be social or relational in nature (Izard, 2010, p. 367).

Consequently, emotions are related to several parts of the organisms and can be influenced by a magnitude of factors (Kallus & Krauth, 1995). Moreover, affective phenomena are typically supposed to consist of several subordinate processes. It is the mutual interplay between these specific processes, which causes the emergence of certain emotional reactions (Larsen & Fredrickson, 1999). Many of the theories describing affective subordinate processes of emotional reactions are based on Izard’s (1977) three-component theory. This theory proposes a reaction triad consisting of neuro-physiological (physiological arousal component) and motoric-expressive (motor expression component) processes as well as the actual affective experience (subjective feeling component). The physiological arousal component thereby comprises visceral reactions, activation in the autonomic nervous system, as well as endocrinological processes (Panksepp, 1998). The motor expression component refers to one's nonverbal behaviour. A person's facial expressions are thereby of particular interest, as this often reflects the affective reaction directly (e.g., Ekman & Oster, 1979). Hence, the subjective feeling of an emotional reaction describes an appraisal of the actual affective experience and is only accessible through introspection (Holodynski, 2006).

Izard (1977) nevertheless warned to evaluate individual components occurring as a complete emotional reaction. Hence, just because there is, for example, an increase in one's physiological arousal, it need not necessarily be an emotion. In his famous component process model, Klaus Scherer (1984, 2001) extended Izards reaction triad by including a cognitive as well as a motivational component. According to Scherer's model, emotions are defined as sequential patterns of appraisals regarding to affective, cognitive, motivational, physiological and motoric-expressive components of emotional experiences. Furthermore, emotional reactions develop and change through the dynamic interplay of these five components. This allows an individual to adapt and flexibly react to changing environmental circumstances. Scherer also collated several organismic subsystems to each of the five components that fulfil specific functions in the development and experience of affective states (see Table 2.1). Accordingly, changes in the organismic subsystem mediate different emotional reactions. Scherer nevertheless points out that apart from an emotional reaction, cognitive, motivational, motoric-expressive, and neurophysiological processes operate independently from each other. The subjective feeling component is assumed to coordinate the processes of the other subsystems in order to ultimately cause a reaction that is referred to as emotion. Hence, one's affective experience here represents the link between the different manifestations of an emotional reaction.

Table 2.1

Emotion Components as well as corresponding Organismic Subsystems and their Functions according to Scherer (1984)

Component	Organismic subsystem	Function
Cognitive	Information processing system (CNS)	Evaluation of internal/external stimuli with regard to behavioural or environmental changes
Neurophysiological	Support system (CNS, NES, ANS)	Energy provision and maintenance of the vital functions
Motivational	Executive system (CNS)	Decision for and preparation of action changes
Motoric-expressive	Action system (SNS)	Communication of emotional reaction
Subjective feeling	Monitor system (CNS)	Monitoring and reflection of the current state of all systems

Note. CNS = central nervous system; NES = neuroendocrine system; ANS = autonomic nervous system; SNS = somatic nervous system.

While the adoption of a motivational component was quite well received, the cognitive component was controversially debated. Lazarus (1984), for example, assumed that the cognitive interpretation of situational stimuli is a necessary precondition for the development of emotional responses in the first place. In Lazarus' view, the occurrence of a specific emotion mainly depends on the subjectively evaluated importance and appraisal of the triggering event. Lazarus (1982) further argued that every emotional reaction is preceded by a primary and secondary evaluation of the situation: While the former appraisal analyses the significance of the current situation with regard to the achievement of personal goals, different ways to deal with possible threats to achieve these objectives are weighed up in the secondary appraisal. However, several authors refuse to ever adopt a cognitive component as part of an emotional reaction. Zajonc (1980), for example, argued that emotions can also occur without any conscious cognitive appraisals. However, neuroscientific findings remain contradictory. In addition, Cacioppo, Gardner, and Berntson (1999) claimed that emotions can emerge automatically and unconsciously based on findings that showed that emotional responses are primarily correlated with subcortical activity. The assumptions of the somatic marker hypothesis proposed by Antonio Damasio and his colleagues (e.g., Bechara & Damasio, 2005; Damasio, Tranel, & Damasio, 1991; Damasio, 1996) even proclaim that every rational decision is grounded in one or several emotional predecessors. In turn, Rolls, Hornak, Wade, and McGrath (1994) found that lesions in pre- and orbitofrontal areas were associated with deficits in socially adequate emotional responses. These areas are considered to be highly important for higher executive functions that include cognitions that can be consciously aware (e.g., Bivona et al., 2008). Ever since, there has been a great number of studies supporting either Zajonc's (1980, 2000) affective or Lazarus' (1982, 1984) cognitive primacy theory. Thus, this emotion-cognition debate has never been ultimately solved (for a review see Damasio, 2003). It is yet to be determined whether a differentiation between cause and consequence of cognitive and affective component is even appropriate. It is therefore supposed that there are conscious as well as unconscious links between affective and cognitive parts of emotional reactions. Accordingly, due to the assumption that emotions consist of multiple dynamically interchanging components, Scherer's (1984) process model managed to integrate these concerns. Thereby, Scherer offers one of the most sophisticated explanation models of what emotions are and how they can emerge.

2.1.2 Differentiation of Emotional Reactions

2.1.2.1 Conceptual Distinctions

Based on Scherer's (1984) component process model, emotional reactions can be separated into different functional processes that interact with each other. However, the outcome of these complex interrelations can appear in various forms. For example, if a person is wrongfully blamed for something he has not done, the person might become angry. In turn, getting angry can manifest quite differently depending on who is getting angry. Some peoples' anger can discharge in a single outburst while other people are only slightly displeased. Analogously, a person's affective reaction can be of shorter or longer duration. For example, a person can be overwhelmed with joy for a short amount of time, e.g., when getting a present. Alternatively, feelings of being happy can persist for a long time, e.g., when living in a fulfilling and satisfying partnership. An emotional reaction can also differ concerning its object focus. For example, people can be mad at someone who was insulting. Otherwise, a person might also be angry with the government or the general development of a country's politics. While the former emotional reaction is directed quite clearly towards a specific person, the latter is not clearly focused on a certain object or person. Thus, several researchers distinguish emotional reactions based on their intensity, duration, and object focus. Temporary but intense affective responses that are caused by concrete internal or external stimuli are often referred to as 'emotions' (e.g., Davidson, Scherer, & Goldsmith, 2003, p. xiii). Affective reactions that are rather unfocused, longer lasting and less intense are quite frequently conceptualised as 'moods' (Gross, 1998; Scherer, 2004). Moreover, moods are supposed to less strongly influence current physiological processes and behaviours of a person than intense emotions (Scherer & Peper, 2001).

However, Pekrun (2006) criticised a categorical distinction of emotions and moods because of imprecise and nebulous boundaries between the two terms. Hence, affects that do not exactly meet the assumptions for an emotion (intense, short duration, clear object focus) or mood (less intense, longer lasting, vague object focus) cannot be conceptualised. In Pekrun's view, emotions and moods may rather be "parts of one and the same multi-dimensional space of emotions, rather than as distinct categories" (Pekrun, 2006, p. 316). Pekrun further refers to moods as low-intensity emotions. Schmidt-Atzert and Hüppe (1996) even argue that affective experiences in everyday situations can only be properly described by seeing them as a compound of moods and intense emotions. Hence, instead of distinguishing between emotions and moods at all, several researchers use the term 'affect' as an umbrella term for all emotional experiences (e.g., Efklides & Petkaki, 2005; McLeod & Adams, 1989). Moreover, the term 'affect' is widely used synonymously with 'emotion' in the Anglophone world rather than in non-English speaking regions (e.g., Gross, 1998).

Scherer (2004) further distinguishes between affective states and traits. Affective states or state emotions are momentary emotional reactions that occur because of specific internal or external triggers in a specific situation. Trait emotions or affective traits otherwise refer to habitual and stable affective states that a person typically experiences in various situations. For example, some people experience anxiety independently from a specific stimulus or situation, whereas a person, who is not easily frightened, may feel fear in a particularly dangerous situation such as seeing a venomous snake.

2.1.2.2 Categorical and Dimensional Classification

Besides a conceptual distinction, affective phenomena can also be classified at the level of their quality. Emotion theorists proclaim at least two approaches, namely, categorical and dimensional affect classification. While the former approach distinguishes different emotional reactions by building nominal classes of affect, the latter approach classifies affect based on their location in a multidimensional space. Both approaches are further discussed in the next sections.

Categorical Affect Classification. Emotion theorists supporting a categorical classification presume that there is a set of emotional reactions, which have, in the course of evolution, proven to be advantageous in dealing with complex environmental demands (e.g., Ekman, 1992; Plutchik, 1980; Tomkins, 1984). Ekman (e.g., 1984) further refers to these reactions as so-called ‘basic emotions’. However, in 1872 Charles Darwin already predicted nominal classes of universal affective reactions, which are unique and emerge independently from each other. Ekman and Friesen (1978) could further show that respondents from different cultural groups were highly compliant in assigning specific facial expressions to certain classes of emotions. For example, lifting the corners of one’s mouth was associated with joy, unbiased by the person’s culture or ethnicity. The authors therefore assume that these basic emotions occur universally and cross-culturally. Accordingly, it is presumed that each basic emotion is describable by a unique facial expression (Ekman, 1971) as well as specific physiological and neural excitation patterns (e.g., Izard, 1992; Roberts & Weerts, 1982; Stemmler & Wacker, 2010; for a review see Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). Several EEG studies found evidence for a lateralization of positive and negative basic emotions with positive emotions being associated with activation patterns in frontal areas of the left hemisphere while similar areas in the right hemisphere were activated when participants reported negative emotions (e.g., Davidson, 1984; Davidson & Tomarken, 1989; Urry et al., 2004). Researcher often refer to the BIS/BAS system (behaviour activation/ behaviour inhibition system; Gray, 1994a,b; Gray & McNaughton, 2008) as a source of asymmetries in frontal EEG activation (e.g., Davidson, 2004; Wacker, Heldmann, & Stemmler, 2003).

Table 2.2

Representatives of the Basic Emotion Approach, adapted from Ortony and Turner (1990, p. 316)

Reference	Fundamental emotion	Basis for inclusion
Arnold (1960)	Anger, aversion, courage, dejection, desire, despair, fear, hate, hope, love, sadness	Relation to action tendencies
Ekman, Friesen, & Ellsworth (1982)	Anger, disgust, fear, joy, sadness, surprise	Universal facial expressions
Frijda (1986)*	Desire, happiness, interest, surprise, wonder, sorrow	Forms of action readiness
Gray (1982)	Rage and terror, anxiety, joy	Hardwired
Izard (1971)	Anger, contempt, disgust, distress, fear, guilt, interest, joy, shame, surprise	Hardwired
James (1884)	Fear, grief, love, rage	Bodily involvement
McDougall (1926)	Anger, disgust, elation, fear, subjection, tender-emotion, wonder	Relation to instinct
Mowrer (1960)	Pain, pleasure	Unlearned emotional states
Oatley & Johnson-Laird (1987)	Anger, disgust, anxiety, happiness, sadness	Do not require propositional content
Panksepp (1982)	Expectancy, fear, rage, panic	Hardwired
Plutchik (1980)	Acceptance, anger, anticipation, disgust, joy, fear, sadness, surprise	Relation to adaptive processes
Tomkins (1984)	Anger, interest, contempt, disgust, distress, fear, joy, shame	Density of neural firing
Watson (1930)	Fear, love, rage	Hardwired
Weiner & Graham (1984)	Happiness, sadness	Attribution independent

Note. *in the original literature cited as "personal communication, September 8, 1986" (p. 316).

While basic emotions are furthermore considered congenital, other ‘nonbasic’ emotional states such as malicious joy or embarrassment emerge as a composition of different basic emotions according to supporters of the basic emotions paradigm (Ekman & Oster, 1979). However, despite a large body of literature on basic emotions there is no consensus on how many basic emotions can finally be adopted. Researchers usually assume between four and twelve emotions that cannot be divided any further and are therefore considered as basic emotions. Ortony and Turner (1990) listed the assumptions of some of the most important representatives of the basic emotion approach (see Table 2.2). Many of the displayed theorists commonly assume negative basic emotions including some kinds of anger, fear, disgust and sadness. One the positive side, emotions like joy, happiness and surprise are most frequently reported. However, researchers differ in the final number of basic emotions. For example, Ekman (1992) further proposed the basic emotion ‘contempt’, while Plutchik (1980a) assumed acceptance, anticipation, and curiosity as core emotions.

Dimensional Affect Classification. Contrary to the categorical approach, researchers who support a dimensional affect classification refuse the assumption of several discrete classes of emotional responses. Instead, dimensional affect classification searches for fundamental dimensions that explain most of the variance in the variety of affective reactions. In order to identify these dimensions, several authors analysed semantic expressions for affective states (e.g., Mees, 1985; Russell, 1978, 1980; Schmidt-Atzert & Ströhm, 1983). Further factorial analyses of the emotion-describing words most frequently resulted in a two-factor solution explaining up to 50% of the variance in emotional self-reports. These two fundamental dimensions were interpreted as valence (with the two poles pleasure vs. misery) and activation (arousal vs. sleepiness). Valence and activation are closely related to two of the three the dimensions Wilhelm Wundt claimed already in the last years of the 19^{th} century, namely, pleasure (pleasant vs. unpleasant) and arousal (arousing vs. subduing). Over the years, several researchers proposed further fundamental dimensions such as tension (strain vs. relaxation; Wundt, 1986), dominance (Russell & Mehrabian, 1977), or alertness (Schimmack, 1999). Empirically, none of these dimensions has been found as meaningful as the valence and activation dimension. Instead, most researchers agree that the first two dimensions can classify affects sufficiently. Consensually, the adoption of further dimensions is not required for a parsimoniously description of affective phenomena.

Using factorial analyses, Russel (1980) further found that adjectives describing different affects such as aroused, excited, pleased, calm, sleepy, sad, miserable, angry, and alarmed can be arranged in a circle with the valence dimension representing the vertical axis and the activation dimension representing the horizontal axis (see Figure 2.1A). This so-called circumplex model of affect (Russell, 1980) consists of four quadrants: The upper-right quadrant represents pleasant-activating affect, the upper-left quadrant represents unpleasant-activating affect, the lower-right quadrant represents pleasant-deactivating affect, and the lower-left quadrant represents unpleasant-deactivating affect. Affects located close to each other on the circumplex are assumed to be closely related, that is, these elements are highly positively correlated. Affects at an angle of 90° otherwise are unrelated respectively uncorrelated. Finally, affects at an angle of 180° are expected to highly correlate negatively.

Although the model has been supported by several authors (e.g., Abele-Brehm & Brehm, 1986; Yik, Russell, & Feldman Barrett, 1999), there are nevertheless critical voices demanding a more elaborated view on the matter (e.g., Feldman Barrett, 2004; Fontaine, Scherer, Roesch, & Ellsworth, 2007; Terracciano, McCrae, Hagemann, & Costa, 2003). According to Daly, Lancee, and Polivy (1983), it has to be considered that the circumplex model cannot sufficiently mirror a neutral affective state.

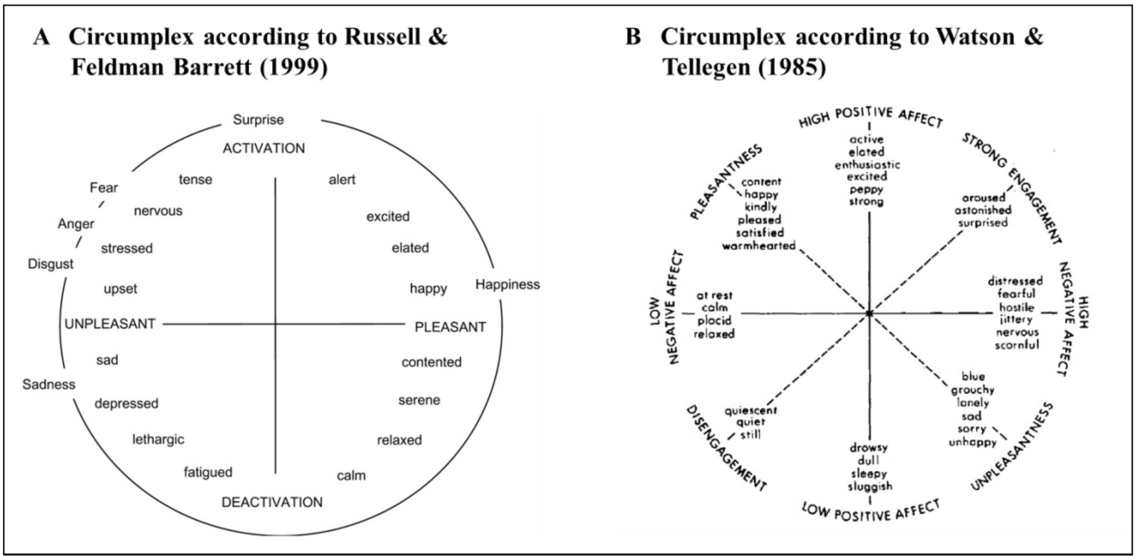

Figure 2.1. The circumplex model (A) according to Russel (adapted from Russell & Feldman Barrett, 1999); (B) according to Watson & Tellegen (1985).

In 1985, Watson and Tellegen presented an extension of Russel's model by rotating the axes of the original circumplex by 45°[2]. The axes obtained with this rotation were located centrally in-between the axes of Russel's model and can be interpreted as a positive affect (PA) dimension and a negative affect (NA) dimension (see Figure 2.1B[3]). According to Watson, Clarke, and Tellegen (1988), PA describes the extent "which a person feels enthusiastic, active, and alert" (p. 1063). NA otherwise is seen as a "general dimension of subjective distress and unpleasurable engagement" (Watson et al., 1988, p. 1063) subsuming negative affects such as anger, fear, nervousness, and disgust. The authors further argued that the PA and NA dimensions are independent

[2] Russel (1980) assumed that there was no best or naturally given arrangement of the axes. They could be rotated at any rate without changing the relationships between the circumplex's elements.
[3] Watson & Tellegen (1985) swapped the poles of the valence dimension before rotating the circumplex by 45°.

from each other and can even emerge simultaneously. The assumption of orthogonality has been criticized for years until Feldman Barrett and Russel (1998) finally concluded that the independence of the PA and NA dimensions can only be assumed for highly arousing affects. Hence, PA and NA do not refer to all positive respectively negative affects but only to those associated with high levels of activation. Due to possible misconceptions, Tellegen, Watson, and Clarke (1999) later relabelled the dimensions into positive and negative activation (acronyms were maintained).

Certain considerations were made on whether to favour the original circumplex according to Russel (1980) or to rely on the version of the circumplex as proposed by Watson and colleagues. The former model asks for one's actual experiences in terms of valence and activation separately, while the latter model questions a person's positive and negative activation in specific situations. The PA/NA-model therefore has advantages when assessing application-oriented data due to its direct reference to everyday life. Moreover, Watson et al.'s model allows converting levels of PA and NA into the valence dimension by simple subtraction. Furthermore, the sum of PA and NA scores can be used to describe a state of valence-free activation when both are equally strong.

Comparing categorical and dimensional affect classification leads to the conclusion that none of the approaches is generally preferable, although several researchers argue either in favour for the categorical (e.g., Larsen & Diener, 1992) or the dimensional approach (e.g., Scherer & Wallbot, 1994; Wierzbicka, 1992). Zachar and Ellis (2012) give a detailed comparison on the affect classification debate. Accordantly, a categorical concept is more useful in order to differentiate discrete emotions by their qualities. This is of particular importance, if the emotions of interest are located within the same quadrant of the circumplex. For example, dimensional classification systems cannot differentiate between different manifestations of negative activation like anger and fear although both states are obviously distinguishable emotional reactions. The dimensional approach nevertheless succeeds in measuring a person's general affective condition that includes several, even opposing affective states more appropriately as well as economically than using the categorical approach. Moreover, sharp distinctions between discrete emotional categories are less likely to assume in everyday life situations (e.g., Davis et al., 1995; Herbon, Peter, Markert, van der Meer, & Voskamp, 2005).

2.1.3 Derivation of an Operational Definition

Emotion theorists argue that there is no commonly accepted definition of affect, mood or emotion (e.g., Frijda, 1986; Izard, 2010). Thus, emotions are often defined as temporarily but intense affective states, which are caused by concrete internal or external stimuli (Davidson et al., 2003). Moods otherwise are seen as rather unfocused, longer-lasting and less intense states (see Gross, 1998) whereas affect is generally used as an umbrella term for all emotional experiences (Efklides & Petkaki, 2005; McLeod & Adams, 1989). Other authors criticize this sharp distinction and refer to a dimensional conception of affective experiences (e.g., Pekrun, 2006). In this view, all affective states differ in their locations in the same multi-dimensional space. Furthermore, a distinction is made between affective states that occur only temporarily due to an acute internal or external stimulus and one's habitual disposition to experience specific affects in various situations (called affective traits or affectivity; see e.g., Watson & Clark, 1984). There exist at least two different approaches for distinguishing different kinds of affect. Categorical affect classification assumes a set of evolutionary adapted, cross-cultural basic emotions of which all other affects are composed (Ekman, 1992). Although several researchers agree on some of the basic emotions, it is still relatively controversial, which and how many basic emotions can be assumed. Dimensional affect classification otherwise seeks to identify those underlying dimensions, which are most suitable in distinguishing different affects. Among others, Russell (1980) proposed at least two bipolar dimensions of affect, namely, activation and valence. Given an orthogonal structure of these dimensions, this distinction is often referred to as the circumplex model of emotions (e.g., Feldman Barrett & Russell, 1998; Yik et al., 1999). Several works by Watson and colleagues (e.g., Watson et al., 1988; Watson & Tellegen, 1985) propose a rotated version of the circumplex that consists of the two dimensions positive and negative affect respectively activation. This model is advantageous when assessing affective states in everyday-life situations. Moreover, the original circumplex scales can easily be calculated.

In his component process model, Scherer (1984) further defines emotional reactions as different patterns of appraisals regarding to affective, cognitive, motivational, peripheral physiological and expressive components of emotional experiences. Each of these components is linked with an organismic subsystem, which fulfils specific functions in the development and experience of affective states. Due to this multi-componential definition of affective states, separating emotional, cognitive and motivational aspects of affect seems not to be expedient. For the purpose of this work, it seems sufficient to refer to the assumptions of general affect rather than specific emotions. Due to its advantages, the revised circumplex proposed by Watson and Tellegen (1985) is preferred. Therefore, in the present work the term 'affect' is used synonymously with 'mood' or 'emotion' and describes a two-dimensional affective state, referring to the dimensions of activation and valence. In order to avoid misunderstandings in the terminology, the terms ‘positive activating affect’ and ‘negative activating affect’ are further used to describe positive and negative affect in the sense of Watson and colleagues, that is, feelings of activeness, elatedness, and enthusiasm (positive activating affect) or feeling distressed, fearful, or nervous (negative activating affect).

2.2 Affect and Learning

Educational research mainly concentrated on cognitive processes that are related to learning outcomes (e.g., the cognitive load theory, Sweller, 2005; Sweller, van Merrienboer, & Paas, 1998; or the cognitive theory of multimedia learning, Mayer, 2005, 2009). Nevertheless, the crucial influence of affective states on learning is commonly accepted (Kim & Pekrun, 2014). For example, Craig, Graesser, Sullins, and Gholson (2004) found that affective states that occur while learning account for 27% of the variance in learning gains. As mentioned in chapter 1, research on affect in academic situations has strongly increased over the past decade (Pekrun & Stephens, 2011). Until the turn of the millennium, most of the research in this field concentrated on test anxiety (e.g., Zeidner, 1995, 2007) or motivational traits (Ainley, 2006; Ainley & Ainley, 2011). In the last years, the investigation of other affective states like confusion or flow in academic settings became more popular (D’Mello & Graesser, 2012; Kort, Reilly, & Picard, 2001). Thus, it is assumed that affective states change dynamically while learning (e.g., D’Mello & Graesser, 2012). Moreover, these states can directly impact learning-related cognitive and motivational processes such as self-regulation, creative problem-solving, the use of learning strategies or intrinsic motivation (e.g., Efklides, Kourkoulou, Mitsiou, & Ziliaskopoulou, 2006; Erez & Isen, 2002; Linnenbrink & Pintrich, 2002a,b).

2.2.1 Basic Concepts

According to Pekrun, Götz, Titz, and Perry (2002), affective states that are 'directly linked to academic learning, classroom instruction, and achievement' (p. 92) can be defined as learning-related affects or, if referring to discrete affective states, academic emotions[4]. Examples include pleasure while learning, hope of passing a certain exam or shame because of a bad performance. Works by Reinhard Pekrun and several colleagues (e.g., Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Stephens, 2011) assume four types of academic emotions: Epistemic emotions, topic emotions, social emotions, and achievement emotions[5].

Epistemic emotions are induced by the cognitive processing of perceived information such as the feeling of certainty towards answering in an exam. The authors further propose the so-called "cognitive incongruity" (Pekrun & Stephens, 2011, p. 5) as a prototypical cause of epistemic emotions. Cognitive incongruity arises when the learner faces information in the learning situation that is hard to understand or even contradicting to his or hers prior believes. As a result, learners first may be surprised or curious due to the unexpected information. Depending on how the information is further processed, various other discrete emotions can arise. If the surprise persists, feelings of confusion or even curiosity can occur. Anxiety might be experienced when the contradictions are rather serious, for example, when a person's fundamental cognitions and believes are challenged. If the incongruity can be resolved by, for example, applying an effective learning strategy to overcome the learning obstacle, the learner

[4] The term 'academic emotion' is sometimes used as an umbrella term for all learning related affective states. However, several works of Pekrun do incoherently sometimes use the term synonymously with 'achievement emotion'.
[5] Although Pekrun and colleagues manage to distinguish between these types, there are no strict boundaries given the dynamic structure of emotional reactions.

may experience feeling of enjoyment or relief. Otherwise, learners may get frustrated or bored. These assumptions are quite similar to the cognitive equilibrium framework proposed by D'Mello and Graesser (2012).

Social emotions do not only refer emotions that occur as a consequence of social interplays between people in achievement situations, but also to a learners' emotions that are socially related such as envy, contempt, or admiration. For example, one can experience envy against someone who received higher grades in class even if the person is not physically present. Pekrun and Linnenbrink-Garcia (2012) further argued that social emotions also refer to non-academic emotions such as falling in love with somebody in their own class. Furthermore, the authors assume that social emotions can crucially affect a learner's achievement motivation as well as his or her interpersonal relations in the classroom.

Topic emotions are elicited through the content of the learning material such as interest for the learning topic or sympathy for pedagogical agents. However, topic emotions quite vividly spread into other contexts apart from education and achievement. Therefore, topic emotions do not necessarily refer to learning, but can increase or impair learning related cognitive, affective, and motivational processes (Kim & Pekrun, 2014).

The last category consists of achievement emotions, which include activity and outcome related emotions. Activity emotions occur directly in the achievement situation (e.g., learning flow), while outcome emotions refer to prospective emotions like the fear of failing in an exam or retrospective emotions like being proud of actually passing an exam. Outcome emotions are typically addressed in correlative studies that investigate the role of emotions regarding the (anticipated) outcome in a certain achievement situation. Research on activity emotions on the other hand often concentrates on the effects of specific emotions like confusion, frustration or delight in the classroom setting (e.g., Ainley & Ainley, 2011) or in computer-assisted deep learning situations (Craig et al., 2004; D'Mello, Craig, Sullins, & Graesser, 2006).

2.2.2 Theoretical Concepts

Despite the general agreement on the importance of affective states while learning, only a small number of theories address emotional experiences in the learning context. In fact, many of the existing theories of self-regulated learning mention affect as a more or less important factor in the learning process (Boekaerts, 1997; Efklides, 2011; Zimmerman, 2008). The next section describes several theoretic approaches on the development and consequences of affective states that occur in achievement and learning situations.

2.2.2.1 Control-Value Theory of Achievement Emotions

Pekrun's (2006) control-value theory (CVT) of achievement emotions is still one of the most sophisticated theoretical frameworks for the development of achievement emotions. Pekrun builds on several key assumptions from the transactional model of stress and coping (Lazarus, 1993; Lazarus & Folkman, 1984), Weiner's (1985) attributional theory, perceived control theories (Perry, 1991), and Pekrun's (1988) expectancy-value model of anxiety. In order to explain the development of achievement emotions, the CVT integrates and expands assumptions from research on situational self-related appraisals. Accordingly, achievement emotions emerge due to an individual's appraisals concerning the (a) subjective value of the learning situation respectively the personal value of the consequences of obtaining a specific achievement outcome, and (b) the person's subjective control over the learning situation. Value appraisals are further differentiated into intrinsic and extrinsic value appraisals. Intrinsic value appraisals are directed towards either the achievement or learning activity or the academic success per se, that is, independent from any advantages of potentials outcomes. An example is valuing the action of learning or succeeding in academic situations without considering any academic benefits. Extrinsic value appraisals include a person's perception of received or anticipated outcomes of achievement situations relating to their usefulness, for example, when a person values learning in order to impress other people or to benefit from good grades. According to Pekrun (2006) intrinsic and extrinsic values build a combined score of a person's value appraisal.

In contrast, control appraisals can be separated into situation-outcome expectancies, action-control expectancies, and action-outcome expectancies as well as causal attributions of specific achievement outcomes. Situation-outcome expectancies describe the amount of one's active participation that is necessary to succeed in a given achievement situation, for example, if a person believes that positive outcomes will occur even without any active participation or if a person assumes academic failure if he or she does not study. Action-control and action-outcome expectancies refer to the learner's perception on whether own actions can actively alter anticipated outcomes. The concepts are thereby closely related to the construct of self-efficacy proposed by Bandura (1986). These three expectancies are further subsumed by total outcome expectancies referring to a person's subjective anticipation on the controllability and probability of certain achievement outcomes. Causal attributions refer to the person's appraisals of the causes of a certain achievement outcome after the outcome is known. According to Pekrun (2006), these attributions are crucial determinants in order to develop achievement emotions retrospectively to achievement actions or outcomes.

Pekrun (2006) further proposes several discrete achievement emotions that occur due to the specific levels of value and control appraisals. For prospective outcome emotions, value appraisals can be positive when a person focusses on succeeding in an achievement situation, or negative, if the person seeks to avoid failure. Control appraisals can be valued as high, medium, or low. Depending on the appraisals' interplay, a learner may experience different discrete emotions in a specific learning situation, such as anticipatory joy (positive value, high levels of control appraisal), anticipatory relief (negative value, high levels of control appraisal), anxiety (negative value, medium levels of control appraisal), or hopelessness (low levels of control appraisals, regardless of the value).

For retrospective outcome emotions, control appraisals are based on the learners' causal attributions of the results obtained, that is, obtained success and failure can be attributed either to oneself or to others. For example, success that is attributed to others rather to oneself may evoke feelings of gratitude, while failure that is attributed to oneself may result in shame. Finally, obtaining results may also elicit affective states that occur without judging its causes. Therefore, succeeding shall generally be associated with joy while failure often entails feelings of sadness. Activity achievement emotions on the other hand can have positive (e.g., liking the action of studying) and negative values (e.g., disliking the action of studying) or no incentive value at all. At high levels of control appraisals, a learner can experience enjoyment (positive value) or anger (negative value). Contrarily, low levels of perceived control lead to frustration regardless of the value. If the activity has no value at all, control appraisals are rather irrelevant and feelings of boredom arise. Table 2.3 shows these relations for pro- and retrospective outcome emotions as well as activity emotions (see chapter 2.2.1).

Table 2.3

Assumptions on the Relation of Control and Value Appraisals and Achievement Emotions in the Control-Value Theory, adapted from Pekrun (2006, p. 320).

	Appraisals		
Object focus	Value	Control	Emotion
Outcome – prospective	Positive (success)	High	Anticipatory joy
		Medium	Hope
		Low	Hopelessness
	Negative (failure)	High	Anticipatory relief
		Medium	Anxiety
		Low	Hopelessness
Outcome – retrospective	Positive (success)	Irrelevant	Joy
		Self	Pride
		Other	Anger
Activity	Positive	High	Enjoyment
	Negative	High	Anger
	Positive/Negative	Low	Frustration
	None	High/Low	Boredom

Pekrun (2006) further argued that achievement emotions crucially influence learning related cognitive, metacognitive and motivational processes (see Figure 2.2). Moreover, the CVT predicts the importance of the environmental circumstances within a certain achievement situation, such as the quality of the learning instructions or the availability or absence of autonomy support. Pekrun (2006) also assumes reciprocal linkages between achievements emotions and their effects as well as antecedents. As displayed in Figure 2.2, the theory also refers to several types of regulation processes affecting each of the main components of the CVT: (a) Appraisal-oriented regulation, (b) emotion-oriented regulation, (c) problem-oriented regulation, and (d) environmental changes. The CVT therefore provides a comprehensive framework on the antecedents and effects of affective states in the learning context.

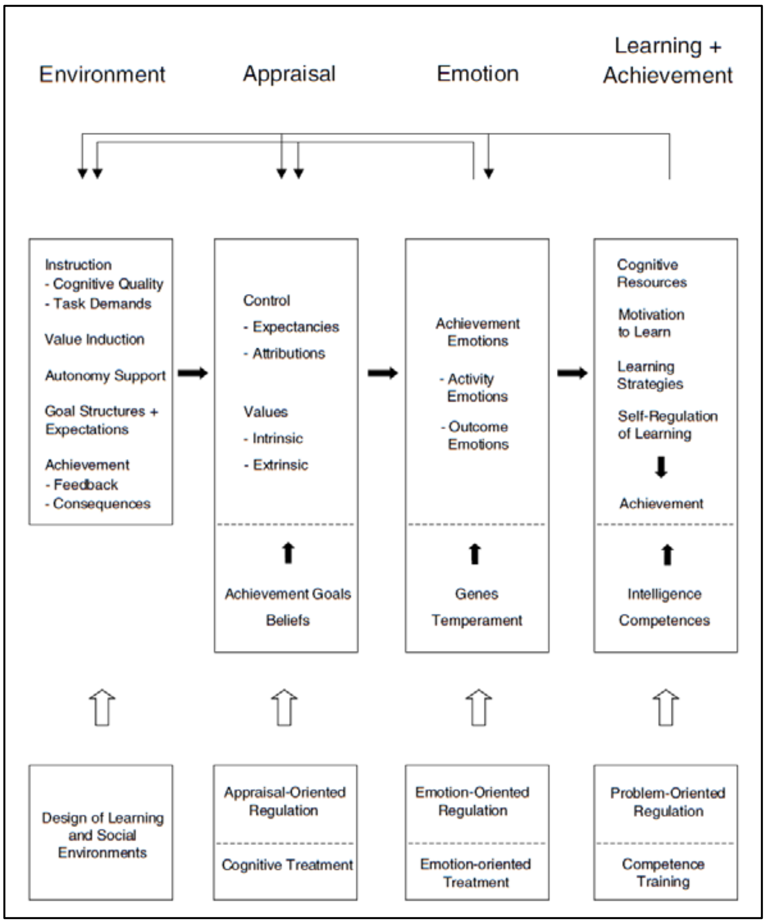

Figure 2.2. Assumptions of the control-value theory of achievement emotions, adapted from Pekrun (2006, p. 328).

2.2.2.2 Resource Allocation Framework

While Pekrun's (2006) CVT offers a holistic view on learning related affective states, other approaches focus solely on negative consequences of emotions in the learning context. According to the resource allocation theory (Ellis & Ashbrook, 1988), affective states should impair learning achievement due to higher levels of task irrelevant thinking. The name derives from the assumed disruption of task-relevant cognitive processes such as memorization and the distraction that emerges when learners become aware of their actual affective experiences. The theory refers to assumptions of the cognitive load theory by Sweller (CLT; e.g., 1988, 2005; Sweller et al., 1998). The CLT assumes that the resources of the working memory for realising cognitive tasks are limited. The theory further supposes three types of load that draw off these resources: (a) Intrinsic cognitive load, (b) germane cognitive load, and (c) extraneous cognitive load. Intrinsic cognitive load includes cognitive processes due to the complexity and difficulty of the learning material itself, for example reading a textbook that is written in a foreign language. Germane cognitive load is related to cognitive resources that are used to actually understanding the learning material, such as the development of new cognitive schemes or the use of meta-cognitive or self-regulatory learning strategies. Extraneous cognitive load on the other hand describes the cognitive effort that comes from the processing of information that is unnecessary for the understanding of the learning material, such as bibliographical excurses on the life of famous scientist alongside the description of their works. It is thereby implied that, if intrinsic and extraneous cognitive load are high, cognitive resources for the understanding of the information is bound.

However, Sweller (2005) also argued that high intrinsic cognitive load due to high interactivity of several elements of the learning material fosters the comprehension of even complex issues. To prevent cognitive resources from being consumed by task unrelated information processing, extraneous cognitive load should be minimized. Furthermore, there are some studies suggesting induced affect as maleficent for learning performance because of enhanced task-irrelevant thinking (Ellis, Thomas, & Rodriguez, 1984; Meinhardt & Pekrun, 2003; Seibert & Ellis, 1991). Ellis and Ashbrook (1988) argued that experiencing and regulating affective states in achievement situations should generate additional extraneous cognitive load and, accordingly, decrease learning outcomes due to the binding of cognitive resources. Although these relationships have not specifically been mentioned by the CLT, Ellis and Ashbrook (1988) refer to them as a basis of the resource allocation theory. However, empirical findings supporting the resource allocation theory mainly concentrate on the effects of negative affective states (e.g., Ellis, Thomas, McFarland, & Lane, 1985). It is therefore questionable whether the learning impairments also occur, if the learners experience positive affect.

2.2.2.3 Cognitive-Affective Theory of Learning with Media

Both, the CVT from Pekrun (2006) as well as the resource allocation theory (Ellis & Ashbrook, 1988) do not specifically address multimedia settings. The former primarily refers to achievement and learning situations in classroom setting, while the latter is settled mainly within the field of basic research concerning memory capacity. Multimedia learning is most commonly defined as the perception and processing of information that is presented simultaneously in several media, e.g., words as well as pictures (Mayer & Moreno, 2003; Moreno & Mayer, 2007). In the cognitive theory of multimedia learning (CTML), Mayer (2009) provides a theoretical framework that describes how verbal and visual information is processed. Based on the dual coding theory (Paivio, 1990) and Baddeley's (1992) model of working memory, the CTML assumes that (a) learners use two channels for information processing (verbal and visual); (b) the amount of information that can be processed in working memory is limited; and (c) to form comprehensive mental representations of content, learners have to actively process the material. The cognitive processing of perceived verbal and visual information is carried out consciously in working memory.

Although several cognitive processes including selection, organization and integration of verbal and visual information are distinguished in the CTML, other important factors such as affect and motivation are not addressed. Therefore, the cognitive-affective theory of learning with media (CATLM; Moreno, 2005; Moreno &

Mayer, 2007) expands the CTML by considering motivational and affective influences on the multimedia information processing as well. According to Pintrich (2003), these factors can impact learning outcomes in terms of decreasing or increasing the learner's cognitive engagement. The CATLM further points out moderating effects of learner characteristics such as prior knowledge or meta-cognitive processes that have been shown to significantly influence learning (e.g., Bannert, 2006; Kalyuga, 2005). Nevertheless, the theory does not sufficiently provide guidelines for implementing these variables in concrete educational material.

2.2.3 Affect and Learning Outcome

Empirical findings indicated that there is a broad variety of learning-related affective states, which appear frequently and change dynamically in the learning situation (D'Mello & Graesser, 2012). There is some empirical evidence that induced affect can foster task-irrelevant thinking and is therefore maleficent for learning outcome (e.g., Ellis et al., 1984). Nevertheless, the results remain contradictory.

Pekrun and Stephens (2011) further note that both positive and negative affect occur at the same frequency while learning. The idea of positive affect being beneficial and negative affect being disadvantageous for learning seems plausible at first glance, but it is not sufficiently supported by empirical findings. According to Pekrun and Götz (2006), positive and negative activating and deactivating affect can have different influences in the learning process. Negative deactivating affect such as boredom or hopelessness is considered to be maleficent for learning outcome because it decreases the learner's intrinsic motivation (Pekrun, Götz, Daniels, Stupnisky, & Perry, 2010; Pekrun et al., 2002). Negative activating affect such as shame or anger is associated with increased task-irrelevant thinking, which may reduce self-regulation, achievement motivation and learning outcome (e.g., Pekrun et al., 2004). Negative activating affect such as anxiety in learning situations may not always reduce achievement motivation but may also lead to more intense studying to avoid the experience of failure (Pekrun, 2006). Additionally, negative activating affect is associated with the use of more narrow, analytical, and in-depth learning strategies (Fredrickson, 2001). However, these findings often refer to correlative studies in which affect and trait variables like achievement motivation are analysed. Furthermore, empirical findings suggest that there are at least some negative affective states, which are associated with learning gains. D'Mello and Graesser (2012), for instance, found positive correlations between confusion and learning gains using automatic affective tutoring systems to investigate learning-related affective states. The authors further argue that confusion while learning is central for comprehending complex learning materials because it triggers regulation techniques meant to overcome this affective state. Therefore, learners may, for example, invest more mental effort in understanding a certain learning topic in order to overcome their feelings of being confused (for an overview, see D'Mello & Graesser, 2014). Findings concerning positive affect while learning are also rather heterogeneous. Positive deactivating affect such as relaxation is associated with the use of more superficial learning strategies and can reduce motivation to work on challenging tasks because it encourages the learner to believe that there are no problems in the learning process (Aspinwall, 1998; Pekrun, 2006). Positive activating affect such as flow or enjoyment, on the other hand, may strengthen learning outcomes. Several findings assume that these affective states are related to broadened attention, better memory storage and retrieval and higher levels of task persistence (e.g., Efklides et al., 2006; Fredrickson, 2001).

Another line of research frequently found that positive activating affect enhances creative problem-solving as well as cognitive flexibility in decision making (e.g., Isen, 2000; Isen, Daubman, & Nowicki, 1987; Isen, Rosenzweig, & Young, 1991). Moreover, positive activating affect is correlated to better learning outcomes (Pekrun et al., 2002). Although Pekrun and Stephens (2011) argue that general positive affect may not enhance learning outcomes because it includes deactivating affective states such as relaxation that may decrease motivation, some studies found an increase in learning outcome when general positive affect is elicited (e.g., Nadler, Rabi, & Minda, 2010). To summarize, positive activating affect is positively correlated with learning-related cognitive processes, whereas negative deactivating affect is associated with lower levels of learning motivation and poor performance. Empirical findings concerning negative activating affect and positive deactivating affect appear contradictory. Nevertheless, although causal relationships between positive activating affect and learning gains are often implied, most empirical findings are still based on correlational studies. Therefore, experimental studies are required to test if positive activating affect causes an increase in learning. Recent studies done by Um, Plass, Hayward, and Homer (2012) and Plass, Heidig, Hayward, Homer, and Um (2014) addressed this issue by inducing positive activating affect in a multimedia learning environment. Results showed that participants who learned in a multimedia environment designed to elicit positive activating affect showed higher levels of learning gains compared to participants in an affectively neutral control condition. Yet, the induction of positive activating affect while learning may strengthen learning outcomes. The authors further refer to these findings as the "emotions as facilitator of learning hypothesis" (Um et al., 2012, p. 487).

2.3 Affect and Achievement Motivation

Achievement motivation is traditionally defined as “affect in connection with evaluated performance in which competition with a standard of excellence was paramount” (McClelland, Atkinson, Clark, & Lowell, 1953, pp. 76–77). This indicates a close connection between achievement motivation and affect. However, similar to the search for a common definition of affect, achievement motivation is seen disparately depending on the researcher’s view on the matter. Most of the early theories on achievement motivation assume a close interaction between personal traits and situational factors (Atkinson, 1957,1974; Heckhausen, 2006). In addition to, for example, intelligence, extraversion, or trait anxiety, motivational psychologists assume so-called motives as personal traits that can cause action tendencies. Motives are seen as enduring, highly generalized characteristics of the person to favour certain classes of incentives (Rheinberg, Vollmeyer, & Burns, 2001, p. 58). One of the most studied motives is the achievement motive that is separated into the two constructs hope for success and fear of failure (Heckhausen, 1963). Situational factors, which are involved in the development of motivated human behaviour, are called positive or negative incentives. Positive incentives fit to the motive of the person and therefore trigger approaching behaviour such as voluntarily participating in an interesting or important lecture. Incentives that do not fit to the person’s motives (negative incentives) otherwise result in avoidance behaviour, for example, staying away from a lecture that is not important in order to succeed in one’s studies.

Based on these early works, numerous expansions as well as opposing approaches were published. This resulted in various concepts and theories on achievement motivation in general or on specific aspects of the construct, as for example, expectancy-value models (e.g., Eccles et al., 1983), Atkinson's (1957) risk preference model, Bandura's (1986) social-cognitive theory, the self-determination theory by Deci and Ryan (e.g., 2009), volitional (e.g., Kuhl, 1983; see also Heckhausen & Gollwitzer, 1987 for an introduction into the rubicon model of action phases) and attributional models (e.g., Weiner, 1985), as well as models including situational and personal interest (e.g., Schiefele, 2009) or the occurrence of flow (Csikszentmihalyi, e.g., 1975, 2010). However, within the field of achievement motivation research, the achievement goal approach (e.g., Ames, 1984; Dweck, 1986; Nicholls, 1984) is still one of the most important theoretical frameworks (for a review see Elliot, 1999). Moreover, the relationship between achievement emotions and goal orientations has been investigated frequently. Hence, the achievement goal approach and its relevance for affect in the learning process are described more detailed.

Affect and Achievement Goals. Achievement goals cause task engagement in achievement settings and determine the individual's perception of such situations (Maehr, 1989). Most achievement motivation theorists assume at least two types of achievement goals, namely mastery or learning goals and performance goals (e.g., Ames, 1992; Dweck, 1986). Individuals with mastery goal orientation learn in order to improve existing or to develop new abilities and knowledge (Ames & Archer, 1988). Mastery achievement goals are often positively correlated with a variety of learning-related outcomes and processes, including effort, motivation to work on challenging tasks, and performance (Ames, 1984; Elliot & Dweck, 1988; Philips & Gully, 1997; VandeWalle, Brown, Cron, & Slocum, 1999). Moreover, empirical findings suggest that mastery goals are usually positively related to performance in challenging tasks (Grant & Dweck, 2003), intrinsic motivation (Rawsthorne & Elliot, 1999) and the use of deep processing strategies (Elliot & McGregor, 1999). Moreover, mastery goal orientation is associated with higher perceptions of academic skills and self-efficacy (e.g., Meece, Blumenfeld, & Hoyle, 1988). Performance achievement goals on the other hand are related to social comparisons in the achievement setting and often impair learning outcomes (e.g., Dweck & Leggett, 1988). Nevertheless, empirical findings are somewhat inconsistent. Meece, Herman and McCombs (2003), for example, found positive correlations between performance achievement goals and measures of self-efficacy as well as the use of active learning strategies. Therefore, in the hierarchical model of approach and avoidance achievement motivation, Elliot (1997) and others (e.g., Elliot & Harackiewicz, 1996; Elliot & McGregor, 1999) further classified performance goals by valence into an approaching success type (performance approach goals, e.g., the goal of outperforming others) and an avoiding failure type (performance avoidance goals, e.g., the goal of hiding one's weaknesses from others).

Empirical findings suggest that performance approach goals can also enhance performance in achievement situations (e.g., Darnon, Harackiewicz, Butera, Mugny, & Quiamzade, 2007). Contrarily, performance avoidance goals are generally considered to reduce learning outcomes (e.g., Elliot & Church, 1997; Linnenbrink, 2005). In sum, a predominant effect of mastery goal orientation on learning outcomes is commonly accepted, although there is some evidence that mastery goals are only beneficial when the learning task is relatively complex (for a meta-analysis, see Utman, 1997). Later, Elliot (1999) and Elliot and McGregor (2001) proposed a 2 × 2 model of achievement goals in which mastery goals were also divided into approach and avoidance types. Because the 3-factor model typically associates mastery goals with approach behaviour, e.g., to gather knowledge or to improve one's own abilities, these goals correspond to mastery approach goals in the 2 × 2 framework. Mastery avoidance goals on the other hand represent the goal of not making any mistakes or misunderstanding the learning contents. Elliot and McGregor (2001) assume that these goals are less beneficial for learning outcomes compared to mastery approach goals because the failure-avoidance component should have an impairing effect. Nevertheless, empirical evidence for the 2 × 2 model is still rare.

According to Pekrun (2006), achievement goals and learning-related affect are strongly connected, which is why much research has been performed on the relationship between these two theoretical constructs. However, empirical findings concerning positive affect and achievement goals are not conclusive. Numerous studies found positive associations between mastery goals and positive affect (Gerhardt & Brown, 2006; Ryan, Patrick, & Shim, 2005), while slightly negative or null correlations were frequently found for positive affect and performance avoidance goals (e.g., Fortunato & Goldblatt, 2006; van Yperen, 2006). Performance approach goals on the other hand show a more diverse pattern. Whereas several studies found negative correlations with positive affect (e.g., Ryan et al., 2005), there are also conflicting results indicating a significant positive relationship (e.g., Linnenbrink, 2005; Sideridis, 2006). However, in a recent meta-analysis by Huang (2011), positive affect and mastery goal orientation were positively correlated, with an average correlation of .48. In contrast, performance approach goals and performance avoidance goals were slightly positive and negatively related to positive affect, with average correlations of .14 and -.10, respectively. As mentioned in section 2.1.3, positive affect includes activating as well as deactivating affective states such as relaxation or relief. Because the latter are assumed to decrease learning outcomes, it is necessary to consider these states separately. According to

Pekrun, Elliot and Maier (2006), most studies on the relationship of achievement goals and affect did not distinguish between activating and deactivating affective states. The authors therefore investigated distinct positive activating emotions (enjoyment, hope and pride) and found significant positive correlations with mastery goals (ranging from .22 to .30) and null to slightly positive correlations with performance approach goals (ranging from .00 to .22) as well as avoidance goals (ranging from -.01 to .15). Recent studies by Putwain and colleagues (Putwain & Deveney, 2009; Putwain, Sander, & Larkin, 2013) supported these findings. Therefore, positive activating affect is positively related with mastery goals and to a limited extent with performance approach goals as well. Performance avoidance goals appear not to be related to positive affect.

2.4 Open Questions and Research Goals

Research on the educational effects of affective states has found contradictory results. Deactivating positive and negative affect has typically found to be maleficent for learning. Activating affective states otherwise have shown to form more complex picture. Whereas discrete negative activating emotions like anger or shame tend to impair learning processes, feelings of anxiety and confusion may also have positive effects on the learning outcome, at least under certain circumstances (Pekrun & Stephens, 2011). It remains unclear, whether general negative activating affect influences learning outcomes. Similarly, some findings indicate that positive activating affect can be beneficial for learning (Pekrun et al., 2002), while other studies did not find this relationship (e.g., Linnenbrink, 2007). A recent meta-analysis by D'Mello (2013) shows that positive activating affective states like being engaged are most frequently reported during complex learning situations. Hence, positive activating affect is obviously an important factor in the learning process. Moreover, as illustrated in section 2.2.3, these affective states can incrementally enhance learning outcomes. Nevertheless, little is known about the causal influence of positive and negative affective states in short-time learning situations because most of the present studies examine affect and learning over bigger spans of time (e.g., school years or semesters) or refer to correlational designs. Accordingly, research on the causal relationship between positive activating affect that occurs directly while learning and learning outcome is still relatively rare. Furthermore, the role of motivational factors in the learning process as well as the relationship between achievement motivation and affective states while learning is still controversially. The main objective of this work is therefore to examine the causal effects of affective states on learning outcomes in terms of performance and achievement motivation. Works by Um et al. (2012) and Plass et al. (2014) give initial experimental evidence for learning enhancing effects of positive activating affective states that were induced in a deep learning situation of a relatively short duration. However, opposing effects were found by Knörzer, Brünken, and Park (2016), that is, the induction of negative deactivating affect increased learning outcomes while the induction of positive activating affect led to worse performance compared to a control group. There are also few studies indicating negative effects of negative activating affective states (Schneider, Nebel, & Rey, 2016). Nevertheless, the number of studies is still very low. Moreover, not much is known about the role of possible moderator variables. Consequentially, it is necessary to perform experimental studies in which affect is elicited.

Affect induction procedures thereby have been examined in scientific studies for decades resulting in a broad variety of methods. In a meta-analysis, Westermann, Spiess, Stahl, and Hesse (1996) found that the presentation of films clips as well as reading emotionally charged stories were most effective for inducing positive and negative affect. Another popular affect induction procedure that has been used frequently to induce discrete emotions is the presentation of sets of static images as, for instance, in the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997). Alongside, there are numerous other ways of eliciting affective states including the presentation of self-referential statements, the re-imagination of emotionally charged life events, as well as social interactions between participants and role-players. However, most of these methods induce affective states before the actual treatment or stimulus is applied. In contrast, there are affect induction procedures that elicit affects throughout the entire duration of the study such as the use of music or colours (see Westermann et al., 1996 for a rmeta-analysis). In learning contexts, however, affect induction procedures have not been used frequently. Therefore, it first remains unclear which affect induction procedure is suitable in learning settings and second whether affect should be induced before or directly while learning. As an additional aim, this work is designed to gain insight regarding these concerns.

Finally, previous research mainly concentrated on classroom settings. Hence, studies on the relationship between affective states and achievement motivation in multimedia learning environments are still rare. Therefore, the present experiment aims to fill this gap by applying an experimental approach within a multimedia learning setting.

3 Empirical Studies

The next sections describe the experimental studies that were conducted in order to test the presented assumptions on a broader view. The structure of the paragraphs describing the empirical works is similar for each of experiments: First, research aims and, if necessary, an extension of the theoretical background are presented. Second, the experiments' hypotheses are derived. Third, methodological issues are presented including information on sample, study design, materials and the experiment's procedure. Fourth, results are displayed including preliminary analyses in order to control for confounding variables as well as hypotheses testing and, to some extent, post-hoc tests. Fifth, the three experiments are discussed and compared to previous empirical results. Finally, possible implications as well as limitations are presented for each experiment.

3.1 Experiment 1: Inducing Positive Activating Affect before Learning

3.1.1 Research Questions and Hypotheses of Experiment 1

According to the empirical findings presented in chapter 2, affective states can crucially influence learning gains in academic achievement situations (see Craig et al., 2004). However, it also became apparent that randomized control condition design studies pursuing an experimental approach are still underrepresented in this area of research.

The present experiment's general research question is to analyse how induced positive and negative activating affect learning outcome using an experimental approach in order to elicit affective states. Furthermore, achievement motivation in terms of achievement goal orientation is included as a control variable in order to exclude confounding motivational effects on the relationship between affective states and learning performance. Based on the basic principles of inducing affective states in humans (described in chapter 2.4), it was expected that the participants' positive and negative affective states could be manipulated before they were asked to learn. Because positive and negative affective states are considered as two separate unipolar constructs, an affect induction method aimed to induce positive respectively negative affect is further supposed to affect only the affective state of interest. Accordingly, inducing positive affect should let levels of negative affect unaffected, and vice versa. It is therefore hypothesized that:

H1.1a – Participants that receive a positive affect induction report higher levels of positive activating affect before learning compared to a control condition.

H1.1b – Participants that receive a positive affect induction do not report lower levels of negative activating affect before learning compared to a control condition.

H1.2a – Participants that receive a negative affect induction report higher levels of negative activating affect before learning compared to a control condition.

H1.2b – Participants that receive a negative affect induction do not report lower levels of positive activating affect before learning compared to a control condition.

As mentioned earlier in this chapter, the present experiment aims to examine the influence of induced positive and negative activating affect on learning performance. Based loosely on Bloom's taxonomy (1956), learning performance is defined as knowledge, representing the learner's ability to memorize and remember facts and relations between variables, and transfer, which is considered as the ability to transfer knowledge into new contexts. According to the cognitive affective theory of learning with multimedia (Mayer & Moreno, 2003; Moreno, 2005) positive affect can enhance learning performance because it enhances learning related cognitive and motivational processes.

As described in the theoretical conceptions in section 2.2.2 and based on the empirical findings (see chapter 2.2.3), there are two opposing perspectives on the effects of affective states on learning performance: First, referring to the resource allocation theory (Ellis & Ashbrook, 1988), affective states are expected to impair the learning process. This assumption is based on studies which have shown that affective states during learning increase task irrelevant thinking and deplete cognitive resources that are subsequently missing for the actual learning task (e.g., Oaksford, Morris, Grainger, & Williams, 1996). As further described in chapter 2.2.3, several contradictory findings nevertheless show that affective states can also have positive effects. Pekrun & Stephens (2011) argue that findings in line with the resource allocation framework might have occurred because the activation dimension of affective states was often disregarded. This may be true at least for positive affective states. Hence, negative relationships between positive affect and learning are linked rather to positive deactivating affects like feeling relaxed rather than positive activating affect (see Pekrun, 1992). As proposed by the emotion as facilitator of learning hypothesis (Um et al., 2012), positive activating affect on the other hand is linked to positive learning outcomes. Empirical findings indicate that positive activating affect enhances learning related cognitive and motivational processes like attentional deployment, intrinsic motivation and situational interest, the appropriate use of meta-cognitive learning strategies, self-regulated learning, and overall academic performance (see Pekrun & Stephens, 2011, for an overview). Several works from Isen (e.g., Erez & Isen, 2002;

Isen et al., 1987) also highlighted a positive relationship between positive activating affect and creative problem solving. It is therefore hypothesized:

H2.1a – Participants that receive a positive affect induction perform better in knowledge compared to a control condition.

H2.1b – Participants that receive a positive affect induction perform better in transfer compared to a control condition.

Regarding the relationship between negative affect and learning performance, findings rather suggest a negative connection. According to Pekrun and Stephens (2011), negative activating affect can reduce performance due to increased task-irrelevant thinking, which is in line with the assumptions of the resource allocation theory. However, the authors also state that anxiety during learning can also cause high levels of learning motivation in order to comply with the learners' desire to avoid academic failure. D'Mello and Graesser (2012) also argue that feelings of being confused while learning can trigger the use of learning strategies and therefore can be beneficial for learning performance. Negative deactivating affect is assumed to decrease learning performance as well as achievement motivation (see Pekrun, 2006). The present experiment therefore further expects:

H2.2a – Participants that receive a negative affect induction perform worse in knowledge compared to a control condition.

H2.2b – Participants that receive a negative affect induction perform worse in transfer compared to a control condition.

To sum up, the research question of the present experimental study is whether positive and negative activating affect can be induced before learning and whether these states affect learning outcome in terms of knowledge and transfer performance.

3.1.2 Methods of Experiment 1

The following section describes the sample and the design of Experiment 1 as well as the used materials and instruments in detail. Moreover, the procedure of the experiment is described. Materials and instruments used can be found in the appendix,

3.1.2.1 Sample and Design of Experiment 1

For the purpose of Experiment 1, data from 60 volunteers was assessed. Two out of the 60 participants were excluded from the dataset due to difficulties in matching pre- and post-experimental questionnaires. One participant had to be excluded because of language problems. All of the remaining 57 participants were Caucasian and native German speakers. The average age was 20.8 years (*SD* = 2.3; ranging from 18 to 29 years). Thirty-seven (64.3%) of the participants were female. Most of the participants were undergraduate university students (56; 98.2%), one participant declared to be employed. However, the participant did not show striking values in any of the variables. Therefore, the participant was not precluded in the data set. The students were most commonly studying media communication (32; 56.1%), business administration (4; 7%), human computer systems and biochemistry (4; 7% each). Less frequent subjects were theology, business informatics, construction engineering, law, biology, and pedagogy. The students were mostly in their second year of studying with an average study time of 2.9 (*SD* = 2.1) semesters. The participants were invited to the laboratories by using an online recruitment system from a German university as well as social networks. Volunteers could register for one out of several appointments and were tested in groups of up to 10 participants. Each participant was rewarded with an hour of partial course credits or the opportunity to take part in a lottery to win vouchers worth 10 up to 20 euros.

Experiment 1 used a randomised control group design with two experimental conditions and one control condition. The induction of positive, negative, or neutral affective states was the independent variable. Therefore, all participants were shown a film clip before learning in a multimedia learning environment for 20 minutes. Participants in the two experimental conditions were shown either an affectively positive (hereinafter called 'PA condition') or an affectively negative film clip ('NA condition'). Participants in the control condition ('CG') were shown an affectively neutral film clip. Random allocation of participants to conditions ensured that there were no systematic differences between conditions. Affective states were measured thrice as dependent variables: Before watching the films clip (t1), after watching the film clip and before the learning phase (t2), and after the learning phase (t3). Simultaneously, the learners' goal orientations were measured as control variables at t1, t2, and t3. The participants' prior knowledge of the learning topic was measured before the learning phase. After learning, performance in terms of knowledge and transfer was tested as an indicator of learning outcome.

3.1.2.2 Materials used in Experiment 1

Affect induction intervention. To manipulate the learners' affective states before the learning phase, the present experiment used short film clips of videos that were freely available on YouTube. Film clips were edited to a uniform length of 3:30 minutes. The film clip used to elicit positive activating affect showed two German comedians who were contributing in making the other one laugh. The comedians' actions to amuse each other included for instance speaking with a high-pitched voice due to the consumption of helium gas or caricaturing celebrities. For eliciting negative activating affect, a film clip from a German magazine show about criminal youths was used. This film clip concentrated on a news story of a man who was stabbed and murdered from a youth member of a criminal association in an underground station for no reason. Another young criminal from the association later pacifies the actions of the perpetrator in an irreverent way. A third film clip on hydropower was used as an affectively neutral control. This film clip should neither elicit positive nor negative affective states. The film clip concentrated on the structures and mechanisms of a hydroelectric machine. The film clips were presented on identical computer monitors with Full-HD resolution (1920 x 1080 pixels). There were several reasons for using film clips to induce positive and negative affective states in the present experiment. First, film clips have proven to successfully elicit discrete emotions and more general affect (for meta-analyses see Lench, Flores, & Bench, 2011; Westermann et al., 1996) in numerous studies with a medium to large average effect size. Furthermore, film clips are relatively easy to use in laboratory settings due to low levels of demand characteristics (Rottenberg, Ray, & Gross, 2007). Compared to other affect induction methods such as imaginary based induction methods, film clips do not have special requirements as, for example, the participants' ability to recall suitable past experiences. Moreover, film clips are supposed to be independent from the recipient's former emotional experiences, which is why these stimuli are considered to have more consistent effects on different individuals (Kring & Gordon, 1998). Finally, viewing film clips is very common among young people. About 40% of the young German internet users view film clips on YouTube at least once per day (Goldmedia, n.d.). According to the mood management theory (MMT; Zillmann, 1988), using media frequently can satisfy deeply rooted hedonic needs by maintaining positive and reducing negative affective states. It is therefore assumable that young people are used to watch film clips even in periods of stressful academic or achievement situations for mood management purposes. A film-based affect induction method in a learning-related experimental study therefore should not lack in terms of ecological validity.

Learning Environment. The multimedia learning material consisted of seven pages that were written in HTML 5. Each page contained one short learning unit on the superordinate topic of ‘functional neuroanatomy’. Each learning unit contained one main structure of the human central nervous system and provided information on anatomical features as well as typical functions of the structure. In detail, participants learned about the following components: Spinal cord, brain stem, cerebellum, mesencephalon, diencephalon, telencephalon, and prefrontal cortex. Beside written texts of 70 to 100 words, each page also contained a picture of the particular component. Figure 3.1 shows an example of the learning environment.

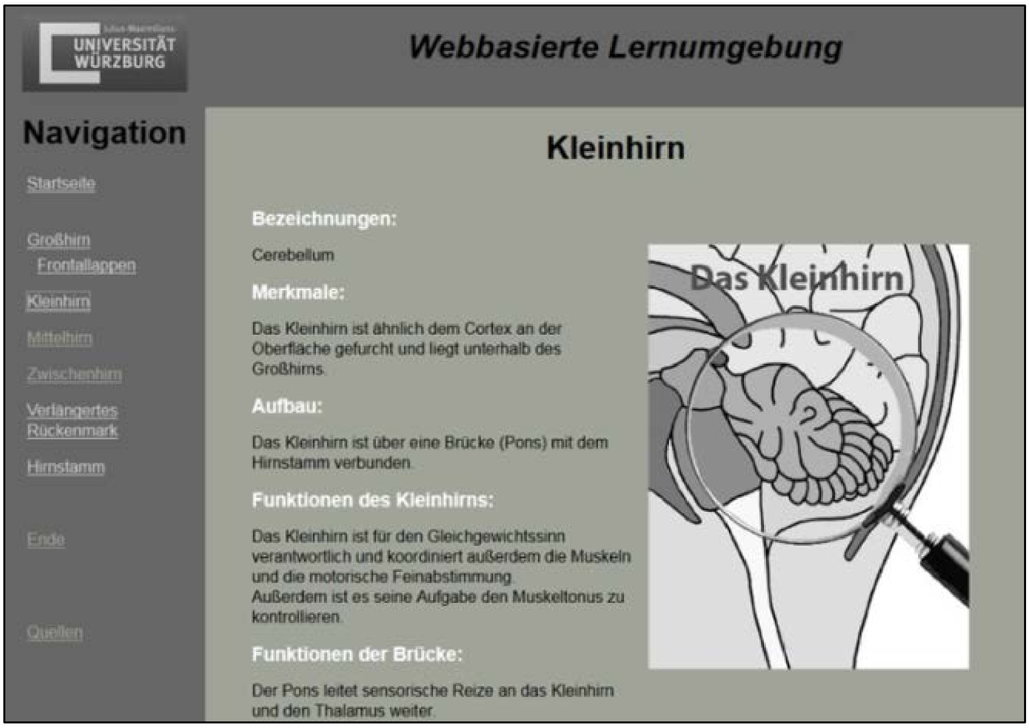

Figure 3.1. Screenshot of the multimedia learning environment used in Experiment 1.

The Mozilla Firefox version 17.0 browser (Mozilla Project, 2012) was used to present the learning environment. A navigation menu on the left-hand side of the screen enabled the participants to navigate through the learning environment. Moreover, they could use the forward and backward button of the browser. Several technical terms were also linked with other sections so that the learner could immediately jump to respective part of the learning material. Taken together, the learning material was about 700 words in written German text and contained seven pictures.

3.1.2.3 Measures used in Experiment 1

Self-Assessed Prior Knowledge. Estimation of prior knowledge was assessed using the following single self-report item: ‘To me, the theme of ‘functional neuroanatomy’ is…’ (a) ‘… completely unknown’, (b) ‘… known, but not actively reproducible’, or (c) ‘… completely known’. Choosing (b) or (c) would have resulted in exclusion from further analysis. In the current sample, all participant chose (a), therefore nobody had to be excluded.

Activating Affect. Affective states were measured using the German version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) translated by Krohne, Egloff, Kohlmann, and Tausch (1996). The scale has been used in numerous studies and has proven to be reliable and valid (Crawford & Henry, 2004). The PANAS is one of the most commonly used self-report scales for measuring affective states and consists of two subscales to assess positive (PA) and negative affect (NA)[6]. According to the two-dimensional model of affect from Watson and Tellegen (1985), PA describes one’s level of being happily engaged. High levels of PA are associated with activity, enthusiasm and attention; low levels imply sadness and drowsiness. NA otherwise is

[6] As described in section 2.2.1.2, the authors later renamed their proposed dimensions into positive and negative activation. As this work measures levels of positive activating affect, the PANAS was well suited to assess the wanted affective states. In order to avoid ambiguities, the original names of the scales are used in this work.

defined as the amount of adverse tension with high levels implying distress and irritability. Low levels of NA are associated with calmness and tranquillity. As displayed by Tellegen and colleagues (1999), positive and negative affect are rather orthogonal and unipolar constructs, that is, a positive activation does not necessarily imply an even negative deactivation. PA and NA are measured with ten items each. The items which consist of different adjectives describing the individual's degree of experiencing different emotionally charged states (PA: Aktiv [active], wach [alert], aufmerksam [attentive], entschlossen [determined], begeistert [enthusiastic], freudig erregt [excited], angeregt [inspired], interessiert [interested], stolz [proud] and stark [strong]; NA: Ängstlich [afraid], erschrocken [scared], nervös [nervous], durcheinander [jittery], gereizt [irritable], feindselig [hostile], schuldig [guilty], beschämt [ashamed], verärgert [upset] and bekümmert [distressed]). Because most of the items are worded in an active style, Watson and colleagues (1988) assume that the PANAS is suitable for measuring activating affective states. The PANAS uses a 5-point Likert-scale ranging from 1 ('very slightly or not at all') to 5 ('extremely'). The PANAS is also supposed to reflect affective states on trait as well as on state level, depending on the instructions used (Watson et al., 1988). General affect can be instructed via 'Indicate to what extent you generally feel this way'. Current affect on the other hand can be measured by using instructions like 'Indicate to what extent you feel this way right now'. In the present experiment, the state version was used because it was aimed to measure changes in affective states rather than general learning related affect. Descriptive statistics for the full sample are shown in Table 3.1. Internal consistencies were adequately high in pre and post measures of positive and negative affect and ranged from Cronbach's α = .77 to .90.

Achievement Motivation. To assess the learner's achievement motivation the SELLMO self-report questionnaire (Skalen zur Einschätzung der Lern- und Leistungsmotivation [Scales for Assessing Motivation for Learning and Achievement]; Spinath, Stiensmeier-Pelster, Schöne, & Dickhäuser, 2002) was used. There are different versions for pupils and students which differ only in terms of item stems ('For me, school is about …' for pupils vs. 'For me, studies are about …' for university students). In this experiment, the version for students was used. The questionnaire consists of 31 items and four scales measuring mastery goal orientation, avoidance performance goal orientation and work avoidance (8 items each) as well as approach performance goal orientation (7 items) using a 5-point Likert-scale ranging from 'not at all' to 'perfectly'. Spinath and colleagues (2002) report coefficients for internal consistence (Cronbach's α) between .75 and .89 as well as evidence for internal and external validity. In the present experiment, the work avoidance scale was not required and therefore excluded for economic reasons. For descriptive statistics of the full sample, see Table 3.1. The internal consistencies in Experiment 1 matched the original data with the lowest value for Cronbach's α = .85. Due to the trait-like character, goal orientations were not expected to change during the experiment. However, to be sure the SELLMO scales were measured three times (along with affective states).

Learning Outcome. Test performance in Experiment 1 consisted of two segments: The understanding of the core content of the learning material ('knowledge') and transferring the content of the learning material into new contexts ('transfer'). Knowledge was measured with 12 single choice items (with four answer options each). The items focused on asking for facts about the different parts of the human brain. To answer the questions, participants had to remember and integrate information derived from one or several positions in the learning material. For example, one item asked: 'Which of the following parts of the brain belongs to the Frontal Lobe? (a) 'premotor cortex', (b) 'supplementary motor cortex', (c) 'autonomic cortex' or (d) 'prefrontal cortex'. The total number of correctly answered items was averaged and used as an index for knowledge. The score in knowledge therefore was between zero, indicating that the learner had not answered any of the questions correctly, and one, indicating that the participants had answered all of the 12 questions correctly. To measure transfer participants had to answer two open-ended questions (for example, 'If there are lesions to specific areas within the prefrontal cortex, the so-called 'Dysexecutive Syndrome' may arise. This disorder usually infects major executive functions of the brain. Which consequences occur if these functions break down?' Two trained student assistants rated the answers from 0 to 3 points (0 = 'wrong answer', 1 = 'answer using correct terms but incorrect linkages between them', 2 = answer using correct terms and partly correct linkages between them', 3 = 'correct answer'). To succeed in answering these questions, it was necessary to integrate facts from different positions within the learning material and transfer these facts to the new problem presented in the question. The mean score per question was used as an index for transfer with a minimum of 0 points, indicating wrong answers in both questions, and a maximum of 3 points, indicating totally correct answers in both questions. Descriptive statistics for the full sample can be found in Table 3.1. For knowledge, internal consistency as indicator for reliability was calculated and considered to be acceptable (Cronbach's α = .72) according to Nunnally and Bernstein (1994). To assess interrater reliability in transfer, Cohen's kappa was calculated between two trained student assistants. The average kappa score was .79 indicating a substantial agreement between the raters according to Cohen (1960).

Table 3.1

Descriptive Statistics of the Variables in Experiment 1 for the Full Sample (N = 57)

	Number of items	Min[a]	Max[a]	*M*	*SD*	Internal consistencies[b]
Positive affect						
t1	10	1.60	4.00	2.67	.57	.82
t2	10	1.40	4.40	2.60	.73	.87
t3	10	1.00	4.10	2.24	.77	.90
Negative affect						
t1	10	1.00	3.00	1.34	.41	.80
t2	10	1.00	3.50	1.53	.63	.87
t3	10	1.00	2.90	1.30	.35	.87
Mastery goal orientation						
t1	8	1.13	4.63	3.03	.88	.90
t2	8	1.00	4.75	3.04	.99	.89
t3	8	1.00	5.00	3.06	.96	.94
Performance approach goal orientation						
t1	7	1.00	3.86	2.00	.73	.85
t2	7	1.00	4.00	1.73	.79	.89
t3	7	1.00	4.14	1.74	.80	.90
Performance avoidance goal orientation						
t1	8	1.00	4.00	1.73	.74	.88
t2	8	1.00	4.00	1.64	.86	.91
t3	8	1.00	4.00	1.59	.85	.94
Performance						
Knowledge	12	.38	.94	.57	.18	.72
Transfer	2	.50	2.50	1.03	.51	.79[c]

Note. t1 = before watching the film clips; t2 = after watching the film clips and before the learning phase; t3 = after the learning phase; [a] Using 5-point Likert scale from 1 – 5 except for performance indicators; [b] Cronbach's alpha; [c] Interrater reliability Cohen's kappa.

3.1.2.4 Procedure of Experiment 1

Data for Experiment 1 was collected in group sessions over a period of two weeks. Participants were welcomed by a student experimenter who had been trained beforehand. To mask the aim of the experiment, the experimenter told the participants that the experiment was about the impact of media reception on a reading task. Participants were first informed about the experiment's general procedure to ensure that they know what to expect. Furthermore, the participants were informed that the shown film material might be emotionally charged. The experimenter also highlighted the volunteers' right to terminate their participation in the experiment at any time unfoundedly, although it was not expected that the material used was unsettling. Conformingly, none of the attendees aborted the experiment. Second, the participants were seated in front of a computer and were asked to follow onscreen instructions to minimize the interaction with the experimenter. Third, to ensure anonymity and to match questionnaires and participants, participants were asked to create an individual identification number, consisting of letters from their parent's names and digits of their dates of birth. Fourth, participants worked on consecutive questionnaires asking for their sociodemographic data and their estimation of prior knowledge. Fifth, affective states as well as goal orientations were measured for the first time (t1). Sixth, participants were randomly shown one of the three film clips and were asked to report their affective and motivational states again immediately afterwards (t2). Seventh, the computer systems automatically presented the multimedia learning environment. Participants were further instructed to read the content of the learning environment carefully and to memorize as much as possible. Eighth, after 20 minutes of learning, the participants were redirected to the post-learning questionnaire and were asked to report their affective and motivational states once more (t3). Ninth, the performance test was conducted. Finally, after answering all questions, the participants were thanked and informed about the real purpose of the experiment. In total, the experiment lasted about one hour. All questionnaires as well as the learning test were administered with 'SoSci Survey' (Leiner, 2014); a free tool for building online surveys, and linked with the hypertext-based multimedia learning environment. Figure 3.2 shows the procedure of Experiment 1.

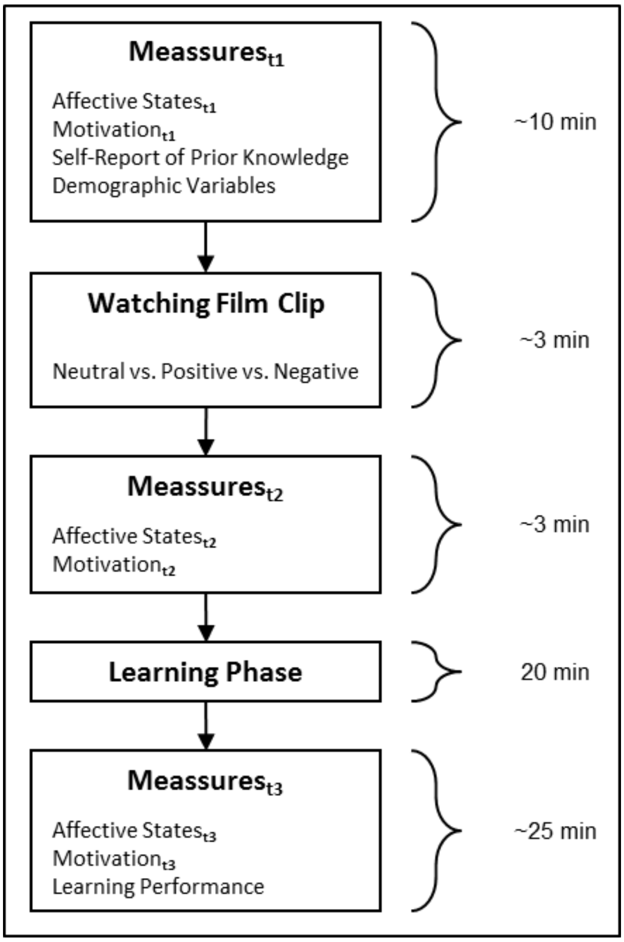

Figure 3.2. Procedure of Experiment 1.

3.1.3 Results of Experiment 1

The statistical analyses were done with IBM SPSS Statistics 22 software (IBM Corp., 2013) using a 5% significance level unless stated otherwise. Differences in affective and motivation states as well as test performance between the participants that saw the positive film clip, the participants that saw the negative film clip and the control condition, who were shown the affectively neutral film clip, were analysed for manipulation checking and hypotheses testing. Normal distribution was checked visually using histograms and statistically looking at skewness and kurtosis and conducting Kolmogorov-Smirnov tests. Homogeneity of variances and covariances were tested by conducting Levenne's tests or Box's *M* tests. Furthermore, item difficulties were calculated. Items that had values lower than .20 were considered as difficult, while items that had item difficulties greater than .80 were considered as easy. In this experiment, none of the items was excessively hard or too easy. Unless stated otherwise, all test assumptions were met in the data analyses. Moreover, differences prior to the learning phase were controlled in order to ensure that the effects of the affect induction were not confounded. For hypotheses tests, regression models were conducted. This approach is advantageous because it allows to consider the influence of covariates as additional predictors in the regression model (see Cohen, Cohen, West, & Aiken, 2003). Accordingly, including covariates as predictors allows for verification of a homogenous influence of the covariates on the effects the independent variable has on the dependent variable (Hayes, 2013).

In Experiment 1, affective states after watching the film clips but prior to the learning phase (i.e. affective states at t2) were further considered as covariates for the regression model for two reasons: (1) According to Watson's and Tellegen's (1985) model, positive and negative affect are orthogonal to each other. It is therefore possible that even when positive (negative) affect is successfully induced, concurrent negative (positive) affect can also predict learning outcome. (2) Due to the dimensional character of affective states, it is further proposed that participants within the same condition differ at least to some extent in their levels of positive and negative affect after watching the film clips. Taking affective states prior to the learning phase into account should control for these within groups variations. As recommended by Eid, Gollwitzer, and Schmitt (2015), the distribution of the externally studentized residuals was visually analysed using scatterplots, histograms, and Q-Q plots in order to check for normal distribution and homogeneity of variances which are necessary assumptions to run the regression models. Externally studentized residuals are defined by dividing an observation's residual by its estimated standard deviation given that the observation is excluded from the estimation of the regression parameters (Eid et al., 2015, p. 683). If the errors are normally distributed and do not differ significantly in their variances, the externally studentized residuals follow a *t*-distribution with $n - k - 1$ degrees of freedom (*df*) with *k* defined as the number of predictors in the regression model. These residuals therefore provide constant variances and give more precise information on violations of the assumptions of the linear model. Moreover, these plots were used to detect possible outliers that may compromise the homogeneity of the data set. Additionally, the data was checked for collinearity between two or more predictors.

3.1.3.1 Preliminary Analyses of Experiment 1

Descriptive Analyses. Table 3.1 shows descriptive statistics as well as indicators of reliability for all of the instruments used in Experiment 1. Measures of affective states as well as achievement goal orientations showed good to excellent values of internal consistencies. This indicates that these measures were reliable at all times of measurement. Reliabilities for learning performance were lower but nonetheless sufficient for research purposes. Looking at minima and maxima of the used scales, it is noticeable, that, except for negative affect, participants used nearly the full range of answering options on the 5-point Likert scales. For negative affect, higher scores were less likely than for positive affect or achievement motivation. This is also evident when looking at the means. Negative affect compared to positive affect was reported on lower levels at all times of measurement. Moreover, values in negative affect did not disperse as much as those in positive affect because of lower standard deviations. This picture is similar for goal orientations, that is, levels of both types of performance goal orientation are lower compared to those of mastery goal orientation. Looking at the change of mean scores across time of measurement, there were only slight changes in any of the variables. Positive affect as well as performance avoidance and performance approach goal orientation declined over time while mastery goal orientation did not vary. For negative affect, descriptive data implies an increase from t1 to t2 and as decrease from t2 to t3. For performance variables, descriptive statistics show that no participants scored extremely bad. For knowledge, the weakest performer was still better as someone guessing. For transfer the weakest performer had answered at least one of the two questions partially correct. It is therefore unlikely that ground effects had occurred. Analogously, because none of the participants achieved the maximum attainable test scores in both tests the probability of ceiling effects can be excluded.

Correlational Analyses. Pearson correlations between all measures are reported in Table 3.2. As expected, positive affective states were correlated highly positive with each other at all times of measurement. The same was true about negative affective states. More importantly, positive and negative affective states were not significantly related at any measure. This supports the assumption of factorial independence between the two scales according to Tellegen and colleagues (1999) and can be interpreted as an indicator of internal validity of the two constructs. Based on the scientific literature, positive correlations should also occur between positive affect and mastery as well as performance approach goal orientation (for an overview see Huang, 2011). Correlations in Experiment 1 mainly supported these findings: Positive affect at t1 and t3 were correlated positively with mastery goal orientation at most of the three measures. Surprisingly, although there was a positive correlation between positive affect at t2 and mastery goal orientation at t1 and t2 these correlations closely failed to become significant.

Table 3.2

Summary of Pearson Correlations between the Measures in Experiment 1 (N = 57)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Positive affect																
1. t1																
2. t2	.76**															
3. t3	.67**	.64**														
Negative affect																
4. t1	.13	.12	.11													
5. t2	.10	.03	.07	.40**												
6. t3	.04	-.07	.02	.69**	.46**											
Mastery goal orientation																
7. t1	.19	.10	.33*	.19	.01	.07										
8. t2	.35**	.22	.44*	.07	.39**	.07	.45**									
9. t3	.39**	.28*	.56**	.06	22	.00	.47**	.91**								
Performance approach goal orientation																
10. t1	.30*	.13	.25	.03	-.01	.01	.50**	.27*	.25							
11. t2	.23	.15	.31*	.18	.03	.20	.16	.42**	.37**	.55**						
12. t3	.19	.15	.44**	.19	.01	.18	.25	.45**	.46**	.49**	.91**					
Performance avoidance goal orientation																
13. t1	.19	.13	.31*	.05	-.02	.10	.40**	.22	.28*	.80**	.47**	.53**				
14. t2	.15	.18	.27*	.32*	.08	.29*	.22	.37**	.37**	.41**	.83**	.85**	.51**			
15. t3	.16	.26	.34**	.29*	.07	.22	.21	.38**	.40**	.37**	.78**	.86**	.53**	.95**		
Performance																
16. Knowledge	-.11	.13	.14	-.12	-.07	-.18	-.05	.01	-.01	-.20	-.05	-.01	-.09	-.10	.02	
17. Transfer	.00	.10	.24	-.14	-.05	-.21	-.05	.06	.04	-.15	.11	.15	-.10	.07	.17	.43**

Note. t1 = before watching the film clips; t2 = after watching the film clips and before the learning phase; t3 = after the learning phase; * < .05, ** < .01

As expected, negative affect was uncorrelated with mastery goal orientation except for t2. Measures of performance approach goal orientation were mostly uncorrelated with affective states, except for positive affect on t3. However, there were correlations that were less expectable, as for instance a mediocre positive correlation between positive affect at t3 and performance avoidance goal orientation. This might have occurred due to changes in goal orientations because of the anticipated learning test, that is, as participants got aware of the upcoming performance test, they might have tried to avoid that other participants noticed their own insecurity. Therefore, group differences in goal orientations at all times of measurement were checked. In line with the literature, different types of goal orientations were correlated highly positive (see Huang, 2011). The most surprising correlations were found between affect states as well as achievement motivation and learning outcomes. Neither affect nor motivation did correlate significantly with learning performance. At descriptive levels, there were negative correlations between negative affect and performance. These correlations were in line with this experiment's assumptions. However, because they did not become significant, results of inference statistical analyses are needed in order to interpret these correlations.

Differences Prior to the Learning Phase. Initial affective and motivational states between the three groups were compared using multivariate analyses of variances (MANOVA) in order to exclude pre-experimental group differences that could confound the effects of the affect induction. A one-way MANOVA with condition as between-subjects factor and pre-experimental positive affect and negative affect as dependent variables was calculated (see Table 3.3 for descriptive statistics). Box's M test, that was conducted prior to the MANOVA, revealed significant violations for the assumption of equality of covariances, Box's $M = 16.36$, $p < .05$. However, Tabachnick and Fidell (2013) argue that Box's *M* test is highly sensitive to even small violations of the assumption. Several authors also claim the *F*-test to be robust against violations of test assumptions; at least if the sample sizes are equal within the subsamples (e.g., Eid et al., 2015; Field, 2013). Because there was an equal number of cases in all of the three conditions and all of the other test assumptions were met, the use of a MANOVA was considered suitable. Tabachnick and Fidell (2013, p. 294) further suggest using Pillai's Trace as an indicator of significance for the MANOVA's Omnibus test, when Box's *M* test is significant. According to the authors, this criterion has proven to be robust against violations of the assumption of equal covariances. The present work followed these recommendations. Using Pillai's Trace, there were no significant differences between the three groups in initial positive and negative affect, $V = .02$, $F(4,108) = .24$, $p = .908$, $\eta_p^2 = .01$. It is therefore appropriate to assume that the three conditions did not differ in their affective states before the film clips were shown.

Table 3.3

Descriptive Statistics of Affective States before the Affect Induction in Experiment 1 (N = 57)

	Number of items	CG (n=19)		PA condition (n=19)		NA condition (n=19)	
		M	*SD*	*M*	*SD*	*M*	*SD*
Positive affect							
t1	10	2.66	.49	2.75	.67	2.60	.56
Negative affect							
t1	10	1.32	.44	1.32	.27	1.37	.38

Note. t1 = before watching the film clips; range of measures between 1 and 5.

For achievement motivation, a one-way MANOVA with initial mastery as well as performance avoidance and performance approach goal orientation as dependent variables was conducted to test for differences between the three conditions. Using Pillai's Trace, there were no significant differences in any of the goal orientation subscales between the three conditions, $V = .08$, $F(6,106) = .72$, $p = .641$, $\eta_p^2 = .04$. Descriptive statistics for the conditions can be found in Table 3.4. It was furthermore controlled, if the randomization was successful by checking for differences between the three groups in age and gender ratio. Conducting a one-way ANOVA with the participants' age as dependent variable did not reveal significant differences between the three conditions, $F(2,54) = .02$, $p = .981$, $\eta_p^2 = .00$. A chi-square test of independence was conducted to test for homogeneity of gender ratio between the three conditions. Results showed that gender was equally distributed, $\chi^2(2, N = 57) = 4.31$, $p = .123$. Hence, it is unlikely that gender or age significantly have influenced measures of the dependent variables differently between the three conditions.

Change in Goal Orientations. In order to ensure that there were no group differences in the change of achievement goal orientation that may influence the effects of the treatment, a 2x3 mixed MANOVA with time of measurement (before and after the learning phase) as within-subjects factor and condition (PA vs. NA vs. CG) as between-subjects factor was conducted for goal orientations (mastery vs. performance approach vs. performance avoidance). Descriptive statistics are shown in Table 3.4. Again, Box's *M* test indicated that there were significant differences in the covariances of the dependent variables, Box's $M = 111.33$, $p < .05$. The MANOVA was still conducted because of equal sample sizes in the three conditions and the robustness of the *F*-test. Using Pillai's trace, the omnibus test revealed no significant interaction effect between time of measurement and condition, $V = .04$, $F(6,106) = 1.35$, $p = .242$, $\eta_p^2 = .07$. Therefore, the three conditions did not differ statistically significantly in their change of achievement goal orientations. However, according to Cohen (1988) an eta-squared of .07, as it was observed for the interaction effect, describes a medium sized effect which should be considered further. Because of the theoretical possibility of making type 2 error due to the relatively small sample size of Experiment 1, univariate ANOVAs were conducted to check for interaction effects. Nevertheless, it had been assured that there was no type 1 error inflation according to multiple testing by adjusting alpha levels. Using the Bonferroni correction, alpha levels were divided by the number of tests in order to not falsely rejecting the null hypothesis.

Table 3.4

Descriptive Statistics of Achievement Goal Orientations in Experiment 1 (N = 57)

	Number of items	CG (n=19)		PA condition (n=19)		NA condition (n=19)	
		M	*SD*	*M*	*SD*	*M*	*SD*
Mastery goal orientation							
t1	8	2.95	.89	3.20	.89	2.95	.89
t2	8	2.61	.94	3.11	.91	3.38	.98
t3	8	2.66	.99	3.30	.99	3.20	.91
Performance approach goal orientation							
t1	7	1.91	.55	2.17	.84	1.90	.68
t2	7	1.48	.55	1.96	.96	1.75	.77
t3	7	1.48	.46	1.98	.99	1.74	.79
Performance avoidance goal orientation							
t1	8	1.59	.61	2.00	.90	1.59	.60
t2	8	1.34	.62	1.99	.98	1.58	.84
t3	8	1.26	.46	1.98	.99	1.64	.86

Note. t1 = before watching the film clips; t2 = after watching the film clips and before the learning phase; t3 = after the learning phase.

The resulting significance level was $.01\overline{6}$, that is, an alpha level of .05 divided by 3 tests. Results of univariate ANOVAs of the interaction effect did not reveal significant differences in performance approach, $F(2,54) = .04$, $p = .961$, $\eta_p^2 = .00$, and performance avoidance goal orientation, $F(2,54) = .33$, $p = .718$, $\eta_p^2 = .01$. Based on the corrected alpha levels, there was a marginally significant interaction effect for mastery goal orientation, $F(2,54) = 3.72$, $p = .031$, $\eta_p^2 = .12$. Descriptive statistics showed that mastery goal orientation slightly increased in the PA condition while it declined in the NA condition during learning (see Figure 3.3).

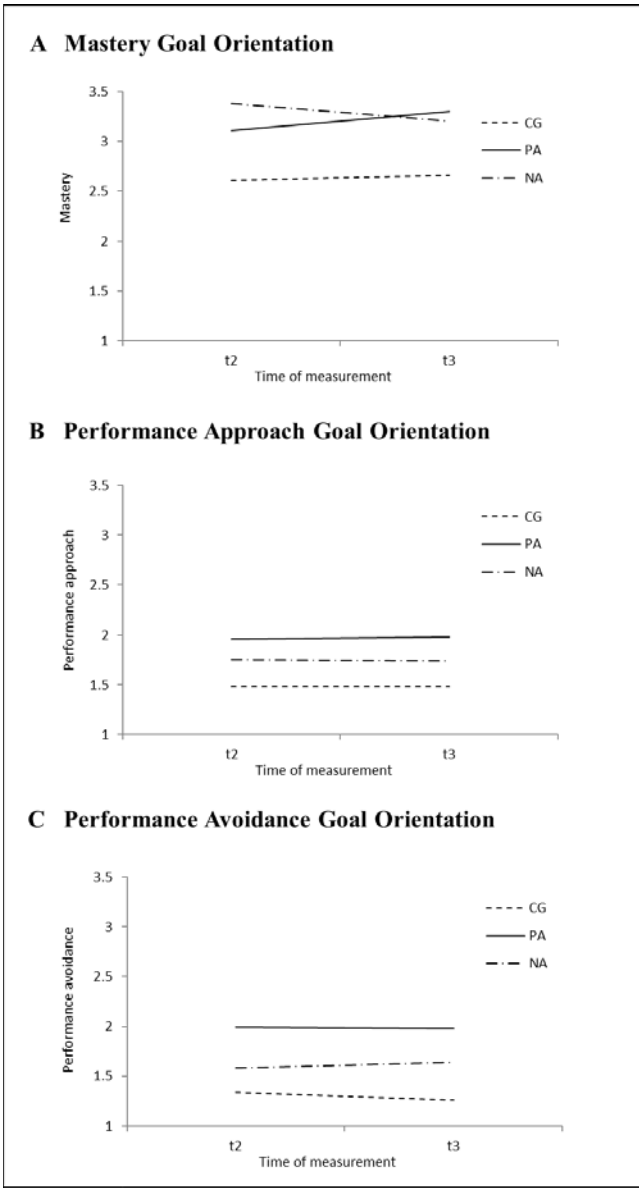

Figure 3.3. Results of Experiment 1's mixed MANOVA with time of measurement (t2 = before learning; t3 = after learning) as within factor and condition (CG = control condition; PA = positive affect condition; NA = negative affect condition) as between factor on achievement goal orientation subscales: (A) Mastery goal orientation, (B) performance approach goal orientation, and (C) performance avoidance goal orientation.

Moreover, there was no significant main effect of time of measurement, $V = .04$, $F(3,52) = .72$, $p = .546$, $\eta_p{}^2 = .04$, but a marginally significant main effect of condition, $V = .19$, $F(6,106) = 1.84$, $p = .097$, $\eta_p{}^2 = .09$. In addition to the interaction effect, univariate ANOVAs were further investigated. However, using adjusted alpha levels of $.01\overline{6}$, there was no significant main effect of condition for any of the achievement goal orientations. It appears more likely that there were no substantial differences in the change of achievement goal orientations during the learning phase as the effects were marginally significant at best. Nevertheless, it is advisable to keeping these findings in mind when interpreting the results of the hypotheses testing.

3.1.3.2 Hypotheses Testing of Experiment 1

Hypothesis 1 – Affect Induction. In Hypothesis 1, it was expected that the presentation of short film clips induces affective states. Participants watching a positive activating film clip should report higher levels of positive affect (Hypothesis 1.1a), whereas negative affective states should be unaffected (Hypothesis 1.1b). On the other hand, participants watching a negative activating film clip were supposed to report higher levels of negative affect (Hypothesis 1.2a), whereas positive affective states should remain stable (Hypothesis 1.2b). To test the effectiveness of the affect induction, a 2x3 mixed MANOVA with time of measurement (before vs. after watching the film clips) as within-subjects factor and condition (PA vs. NA vs. CG) as between-subjects factor was conducted on positive and negative affect (see Table 3.5 for descriptive statistics for each condition). For reasons of clarity, only significant effects are reported.

Table 3.5

Descriptive Statistics of Affective States in Experiment 1 for each Condition (N = 57)

	Number of items	CG (n=19)		PA condition (n=19)		NA condition (n=19)	
		M	*SD*	*M*	*SD*	*M*	*SD*
Positive affect							
t1	10	2.66	.49	2.75	.67	2.60	.56
t2	10	2.34	.63	3.07	.82	2.38	.51
t3	10	2.09	.60	2.56	.98	2.08	.62
Negative affect							
t1	10	1.32	.44	1.32	.27	1.37	.38
t2	10	1.22	.44	1.27	.26	2.10	.68
t3	10	1.24	.37	1.23	.25	1.43	.40

Note. t1 = before watching the film clips; t2 = after watching the film clips and before the learning phase; t3 = after the learning phase; range of measures between 1 and 5.

The Omnibus test of the main effect of time of measurement was significant using Pillai's Trace, $V = .18$, $F(2,53) = 5.66$, $p < .01$, $\eta_p^2 = .18$. Therefore, univariate analyses were checked and revealed a significant main effect of time of measurement on negative activating effect, $F(1,54) = 9.21$, $p < .01$, $\eta_p^2 = .15$. As for the main effect of condition, there was a significant effect for negative affect, $F(2,54) = 8.49$, $p < .01$, $\eta_p^2 = .24$, and a marginally significant effect for positive affect, $F(2,54) = 3.16$, $p = .051$, $\eta_p^2 = .10$. Figure 3.4 shows the change in positive (A) and negative activating affect (B) in the three conditions.

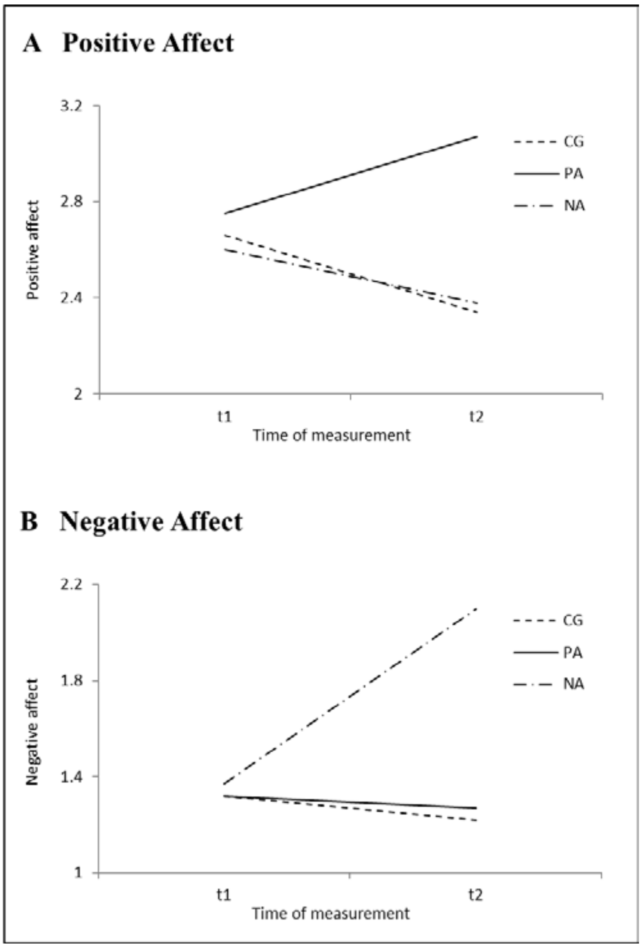

Figure 3.4. Scores of positive (A) and negative affect (B.) using the PANAS scales for the treatment conditions before (t1) and after watching affect inducing film clips (t2) in Experiment 1. CG = control condition; PA = positive affect condition; NA = negative affect condition.

However, when testing a mixed model, the interpretation of main effects is often meaningless and should not be done unless the interaction between the factors is non-significant (see Field, 2013). In the present model, the interaction effect of time of measurement and condition was significant using Pillai's Trace, $V = .72$, $F(4,108) = 15.28$, $p < .001$, $\eta_p^2 = .36$. Univariate tests showed that the interaction was significant for positive, $F(2,54) = 14.09$, $p < .001$, $\eta_p^2 = .34$, as well as negative affect, $F(2,54) = 17.70$, $p < .001$, $\eta_p^2 = .39$. Main effects are therefore no longer interpreted.

As expected, positive affect increased in the PA condition whereas negative affect did not change significantly within those participants. In the NA condition, participants' negative affect increased while positive affect slightly decreased. Participants in the CG also declined in their positive affect. However, in contrast to the NA condition, participants who were shown the neutral film clip did not report higher levels of negative affect afterwards. It is therefore assumed that positive and negative affect have successfully been induced. Hence, Hypotheses 1.1 and 1.2 were met completely.

Hypothesis 2 – Learning Performance. Experiment 1 aimed to examine the influence of positive and negative activating affective states on learning performance. It was assumed that participants in the PA condition should benefit from the affect induction in terms of better learning performance in terms of knowledge and transfer (Hypotheses 2.1a and 2.2a). In contrast, participants in the NA condition should perform worse in the learning tests (Hypotheses 2.1b and 2.2b). The hypotheses were tested using multiple regression analyses. Therefore, the levels of condition were dummy-coded using the CG as reference group. The hypotheses were further tested in three steps: (1) A regression model of performance on condition was calculated to test for differences between the condition without taking potential covariates into consideration (hereinafter named the condition only model), (2) covariates (namely, positive and negative affect prior to the learning phase) were added as predictors into the regression model to check for main effects of these covariates (main effects model), (3) the interactions between condition and covariates and the interaction between the two covariates were added as predictors into the regression model (named interaction model) if there were any main effects of the covariates. Therefore, it was possible to check if the covariates' influence on learning performance was stable among the three conditions. Significant effects would indicate that moderation effects of the covariates occurred, which would have to be considered further. Covariates were centred before they were enclosed in the regression model. Furthermore, to overcome the problem of too many unrelated predictors (i.e. overfitting) non-significant predictors were removed from the regression model, building the final model of the analyses. It should however be noted that there may be restrictions in statistical power due to the limited sample size in the present experiment when adding further predictors to the regression model. There are many rules of thumb concerning the optimal sample size for multiple regression analyses. According to Green (1991), rules of thumb including a subject per variable (SPV) ratio range from 5 to 20 SPV. By including one grouping predictor as well as two possible covariates in the first two steps of the multiple regression analysis, the SPV ratio of the present experiment is just between the two extremes of this range. Therefore, it should be allowed to perform the regression approach.

Table 3.6

Descriptive Statistics of Learning Performance in Experiment 1 (N = 57)

	Number of items	CG (n=19)		PA condition (n=19)		NA condition (n=19)	
		M	*SD*	*M*	*SD*	*M*	*SD*
Learning performance							
Knowledge	12	.58	.17	.58	.19	.56	.19
Transfer	2	1.05	.52	1.05	.54	.98	.46

However, if non-expected significant influences of covariates or interaction effects were found, they could serve as first hints for deriving new hypotheses for future studies. It was therefore important to clarify the influence of these covariates. Results for knowledge and transfer were analysed separately. Table 3.6 shows means and standard deviations for knowledge as well as transfer.

Hypothesis 2.1 - Affect and Knowledge. Table 3.7 shows the model summary for knowledge including all of the tested models. In the first step, dummy coded levels of the PA and NA condition were entered into the regression model as the only predictor. Results showed that this condition-only model did not clarify a significant amount of variance in the knowledge of the learning material, $R^2 = .08$, $F(2,54) = 2.35$, $p = .105$, $f^2 = .09$[7]. The Omnibus test analyses the null hypothesis that independent and dependent variables are uncorrelated and that all regression coefficients do not significantly differ from zero. It is not recommended to interpret components of the regression model when the F-test is non-significant. However, as argued by Tabachnick and Fidell (2013, p. 185) the F-test in multiple regression is highly dependent from sample size and becomes trivial in huge samples. Vice versa, the non-significant overall inferential test does not necessarily imply a null effect in the population. In fact, it can be argued that the effect was simply not strong enough to be detected in the F-test. Therefore, dummy coded regression coefficients of the independent variable were inspected in the present analysis in order to test a priori set hypothesis. However, interpretations of the coefficients will be done with caution due to the relatively small sample size and the

[7] Cohen's f^2 can be used as an estimator of the effect size of a certain predictor and is then defined as R^2 when the predictor of interest is included minus R^2 when the predictor is excluded divided by the variance that is not explained in the regression model ($1-R^2$). If f^2 is used to estimate the effect size for all predictors in the model, which was done in the present analyses, the equation simplifies to R^2 divided by $1-R^2$. Guidelines are given by (Cohen, 1992) indicating a small effect at $f^2 = .02$, a medium effect at $f^2 = .15$, and a large effect at $f^2 = .35$.

non-significant Omnibus test. Moreover, due to the inflation of alpha levels when conducting multiple comparisons and the non-significant Omnibus test, error rates for interpreting regression coefficients were set at .025 per test for the condition only model using the Bonferroni adjustment (the alpha level divided by the number of predictors in the regression model, which is .05 divided by 2 in this specific analysis).

Table 3.7

Regression of Knowledge on Condition and Positive and Negative Affect measured before Learning in Experiment 1 (N = 57)

	Knowledge		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	.810	22.26	< .001
PA condition	.047	.91	.367
NA condition	-.111	-2.16	.035
Main effects model			
Intercept	.795	20.24	< .001
PA condition	.044	.76	.448
NA condition	-.160	-2.48	.016
Positive affect	.008	.23	.817
Negative affect	-.057	-1.27	.210
Interaction model			
Intercept	.779	16.58	< .001
PA condition	.095	1.19	.240
NA condition	-.143	-2.00	.051
Positive affect	.028	.39	.701
Negative affect	-.127	-1.42	.162
PA condition x positive affect	-.005	-.07	.947
NA condition x positive affect	-.123	-1.03	.309
PA condition x negative affect	.236	1.29	.201
NA condition x negative affect	.089	.80	.428
Final model			
Intercept	.904	24.31	< .001
PA condition	---	---	---
NA condition	-.110	1.70	.094
Positive affect	---	---	---
Negative affect	---	---	---
PA condition x positive affect	---	---	---
NA condition x positive affect	---	---	---
PA condition x negative affect	---	---	---
NA condition x negative affect	---	---	---

Note. Condition was dummy-coded in two variables testing the PA and NA condition against the control condition as the reference group each. Positive and negative affect were centered. Dashes indicate that the predictor was removed from the regression model.

Results indicated a marginally significant effect of the NA condition compared to the CG, $b = -.11$, $t = -2.16$, $p = .035$. Inducing negative affect before learning tended to predict worse performance in knowledge compared to a control condition. Contrary to the hypotheses, the induction of positive affect did not predict learning gains in knowledge compared to a control condition, $b = .47$, $t = .91$, $p = .367$. For the next step, the main effects model in Table 3.7, positive and negative affect were added as covariates in the regression model. Results showed that the main effects model did not significantly increase the explained variance compared to the condition-only model, $\Delta R^2 = .03$, $F(2, 52) = .81$, $p = .451$. The model explained $R^2 = .11$ of the variance in knowledge, $F(4, 52) = 1.57$, $p = .196$, $f^2 = .12$. None of the regression coefficients predicted knowledge significantly based on an adjusted alpha level of .0125 (.05/4). Equivalent to the condition only model, there was a marginally significant effect of the NA condition compared to the CG, $b = -.16$, $t = -2.48$, $p = .016$. First order interactions between PA as well as NA condition and affective states (positive and negative) were added to the regression model as predictors in the next step. This interaction model explained about $R^2 = .18$ of the variance in knowledge, $F(9, 47) = 1.15$, $p = .351$, $f^2 = .22$. Neither did the change in R^2 significantly increase compared to the main effects model, $\Delta R^2 = .07$, $F(5, 47) = .83$, $p = .537$, nor did any of the regression coefficients predict knowledge using adjusted alpha levels of approximately .0005 per test (.05/9). For the sake of completeness, second order interactions of condition, positive and negative affect, and a possible interaction between positive and negative affect were tested and found to be non-significant. After removing all non-significant predictors from the regression model to reduce overfitting, the final model only contained the NA condition as predictor for knowledge.

However, the model did explain only a marginally significant amount of variance, $R^2 = .05$, $F(1, 55) = 2.90$, $p = .094$, $f^2 = .06$. Summing up, knowledge was not predicted by the PA condition or positive and negative affective states prior to the learning phase. Therefore, Hypothesis 2.1a had to be rejected. Nevertheless, as it was assumed participants in the NA condition did at least tend to perform worse compared to those in the control condition. Consequently, Hypothesis 2.1b was partly confirmed. As mentioned earlier, these findings should be interpreted cautiously.

Hypothesis 2.2 - Affect and Transfer. To test group for differences in transfer, condition was also dummy-coded, testing PA and NA condition against the control condition as reference (see Table 3.8). In the first step, the condition only model tested the influence of the PA and NA condition. Results indicated that there was no significant effect of condition on transfer after the learning, $F(2,54) = .10$, $p = .908$, $f^2 = .00$. The model further explained less than 1% of the variance in transfer, $R^2 = .00$. Given these results, the hypothesis of positive and negative affect having influence on transfer had to be rejected, if covariates were not considered. However, conducting the main effects model on transfer using positive and negative affective states before the learning phase as covariates did not explain a significant amount of variance in transfer either, $R^2 = .01$, $F(4,52) = .17$, $p = .951$, $f^2 = .01$. Accordingly, the change in R^2 was not significant in comparison to the condition only model, $\Delta R^2 = .01$, $F(4,52) = .25$, $p = .776$. Positive and negative affect before the learning phase did not predict transfer. Consequently, Hypotheses 2.2a and 2.2b had to be rejected. However, hidden interaction effects might nevertheless have significantly predicted transfer. Therefore, the interaction model was conducted entering interactions of PA as well as NA condition and pre-experimental positive affect and negative affect and the interaction between positive and negative affect as predictors in the regression analysis. Although it was not expected that interaction effects occurred, this model explained significantly more variance in transfer than the main effects model, $\Delta R^2 = .22$, $F(4,52) = 3.48$, $p < .05$. However, although this interaction model explained $R^2 = .24$ of the variance in transfer, the overall inferential test was only marginally significant, $F(8,48) = 1.84$, $p = .092$, $f^2 = .32$.

Table 3.8

Regression of Transfer on Condition and Positive and Negative Affect measured before Learning in Experiment 1 (N = 57)

	Transfer		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	1.053	8.98	< .001
PA condition	.000	.01	.999
NA condition	-.063	-.381	.705
Main effects model			
Intercept	1.063	8.32	< .001
PA condition	-.055	-.28	.768
NA condition	-.038	-.18	.856
Positive affect	.077	.71	.481
Negative affect	-.032	-.22	.826
Interaction model			
Intercept	.868	6.39	< .001
PA condition	.426	1.83	.074
NA condition	.045	.21	.831
Positive affect	.217	1.18	.244
Negative affect	-.794	-3.07	.003
PA condition x positive affect	-.257	-1.10	.275
NA condition x positive affect	-.140	-.48	.634
PA condition x negative affect	1.644	3.13	.003
NA condition x negative affect	.959	3.10	.003
Final model			
Intercept	.972	11.58	< .001
PA condition	---	---	---
NA condition	---	---	---
Positive affect	---	---	---
Negative affect	-.571	-2.52	.015
PA condition x positive affect	---	---	---
NA condition x positive affect	---	---	---
PA condition x negative affect	.799	2.12	.039
NA condition x negative affect	.689	2.39	.020

Note. Condition was dummy-coded in two variables testing the PA and NA condition against the control condition as the reference group each. Positive and negative affect were centered. Dashes indicate that the predictor was removed from the regression model.

Regression coefficients were checked using adjusted alpha levels of .00625 per test (.05/8). Nevertheless, there was a significant main effect of negative affect, $b = -.79$, $t = -3.07$, $p < .00625$, as well as significant interaction effects between the PA condition and negative affect, $b = 1.64$, $t = 3.13$, $p < .00625$, and between the NA condition and negative affect, $b = .96$, $t = 3.10$, $p < .00625$. After removing the non-significant predictors from the regression analysis in order to reduce overfitting, the final model explained $R^2 = .13$ of the variance in transfer which was marginally significant, $F(3,53) = 2.69$, $p = .056$, $f^2 = .15$.

To interpret the results, regression lines of transfer were plotted on negative affect for each condition in Figure 3.5. The simple slope of transfer on negative affect was significant for the CG, $b = -.57$, $t = -2.52$, $p < .05$, but neither for the PA, $b = .23$, $t = .66$, $p = .515$, nor the NA condition, $b = .12$, $t = .83$, $p = .410$. Therefore, participants who watched the neutral film clip were more likely to perform badly in transfer when they reported high levels of negative affect before learning.

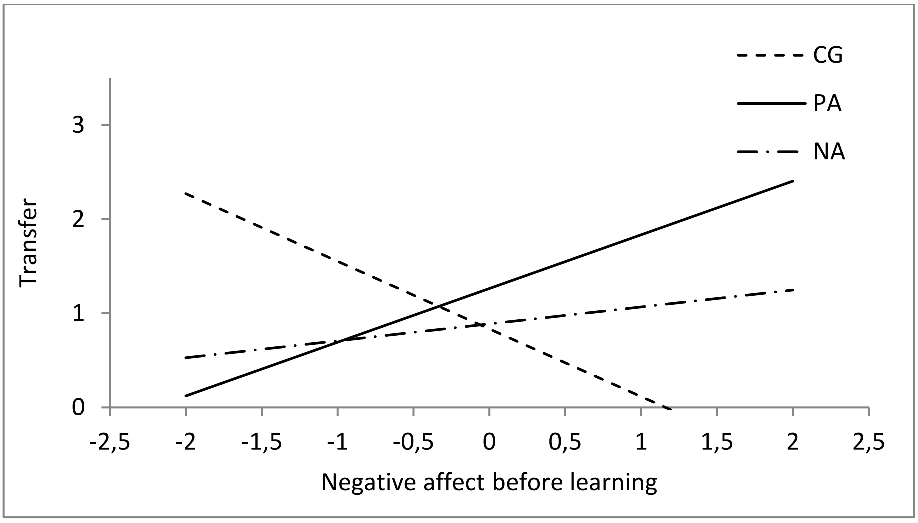

Figure 3.5. Regression of transfer after learning on negative affect before learning for the control condition (CG), the positive affect condition (PA), and the negative affect condition (NA) in Experiment 1. Negative affect was centered, positive affect is held constantly at the average value.

To sum up, results in knowledge and transfer did not clearly support the a priori hypothesized differences in learning performance between the three conditions. For knowledge, there was a tendency for participants in the NA condition to perform worse than the control condition. However, participants who were in the PA condition did not outperform those from the other conditions. For transfer, results were more complex due to an unexpected first order interaction effect between condition and negative affect before the learning phase. When negative affect was high, transfer performance was worse. However, this was only true for the control condition.

3.1.4 Discussion of Experiment 1

In the present experiment, participants were either shown an affectively positive, negative or neutral film clip in order to vary their affective states before learning for 20 minutes in a multimedia learning environment. Positive affective (PA) states were supposed to increase learning outcome in terms of knowledge and transfer while negative affect (NA) should have the opposite effect. Performance in the affectively neutral control condition (CG) should neither has suffered nor benefitted from watching a film clip. The comparison of affective states before and after watching the film clips showed that the affect induction has worked as expected: Watching the positive film clip increased levels of positive activating affect, watching the negative film clip increased levels of negative activating affect, and watching the neutral film clip did not alter affective states at all. However, there were no distinct findings supporting the hypotheses on affective states and learning outcome. Contrary to the hypothesis, participants in the PA condition did not outperform those in the other conditions in test performance. Yet there were some findings indicating that inducing negative affect before learning may impair knowledge performance. Moreover, there were subtle hints of negative affect predicting transfer performance negatively. The next section will further discuss these findings.

3.1.4.1 Differences between Conditions in Experiment 1

Learning Performance. Several studies have found that affective states can crucially influence the learning process (e.g., Craig et al., 2004; Erez & Isen, 2002). Although there are contradicting findings and many not yet completely elucidated questions, it is assumed that positive activating affect can be beneficial for learning. Negative activating affect otherwise can impair learning success (see Pekrun & Stephens, 2011). Results of Experiment 1 nevertheless do not confirm the former assumption, that is, watching the positive film clip causes superiority in knowledge and transfer performance. In fact, there were no significant differences between the PA condition and the control condition in any of the two learning tests. This is contrary to other studies in which positive activating affect predicted better memorization and comprehension of complex learning material (e.g., Fredrickson, 2001; Um et al., 2012) and increased performance in divergent thinking tasks in which the learner had to transfer knowledge into new contexts (e.g., Isen, 2009; Isen et al., 1987).

Results concerning the relationship of negative affect and learning performance were rather heterogeneous. In line with the hypothesis inducing negative activating affect tended to impair learning success in knowledge hypothesis-conformingly, specifically the NA condition performed worse than the other conditions. It is therefore important to note that the findings were not statistically meaningful. However, statistical significance is highly dependent on sample size, that is, the larger the sample the smaller the *p*-values. Vice versa, non-significant *p*-values due to small samples sizes can hide meaningful results in the data. Sample size was rather small in Experiment 1. It is therefore not advisable to rely solely on the inferential *F*-statistics but also to consider effect sizes when interpreting the data. For the impairment of knowledge in the NA condition, the effect sizes were in the range of small to medium effects. Therefore, practical importance is indicated. Thus, given a larger sample, the effects in knowledge may have become significant. In fact, the statistical power analysis program G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) was used for computing the sample size that would have been necessary to achieve significant results in the final regression model in knowledge retrospectively[8]. Results suggest that the NA condition would have been significantly worse in knowledge, if the total sample consisted of four more participants in each group (given that additional participants would behave very similar compared to the rest of the sample). Moreover, univariate ANOVAs and regression coefficients were tested using rather conservative Bonferroni procedure to correct for alpha level inflation. The Bonferroni correction is most frequently used because of its low probabilities of producing type I errors and the easy application. However, there are also constraints using the Bonferroni correction due to raising the chance to conduct type II errors. In sum, effect sizes concerning worse knowledge performance in the NA condition indicate that there is some effect despite nonsignificant *F*-tests. Moreover, sample size in Experiment 1 was more than sufficient to prove a successful affect induction procedure. This experiment's findings therefore show that the negative influence of negative affective states on learning performance is moderate, but effective nonetheless. Consequently, the present results for knowledge can be an indication that inducing negative affect deteriorates learning performance. This is in line with several other studies which also found that negative activating affective states like test anxiety or shame can decrease learning outcomes (e.g., Hembree, 1988; Pekrun, Elliot, & Maier, 2009). Moreover, Pekrun's (1992) cognitive-motivational model suggested

[8]Obtained statistical power and effect size for the final regression model in knowledge were used for this calculation.

negative affect as a source of deflection from the learning task that can impair the learning process by decreasing achievement motivation. Pekrun (2006) also argued that, depending on parameters of the specific achievement situation and the learner's personality traits, negative activating affective states may also enhance achievement motivation because of the learner's desire to avoid failure.

As previously mentioned these findings are mostly based on correlative data and should therefore not be interpreted causally. However, Experiment 1 succeeded in demonstrating a moderate negative effect of negative affective states on knowledge by applying a relatively small experimental intervention (watching film clips for three and a half minutes before learning). For the relationship between negative affect and performance in transfer, findings were more complex. Although not initially assumed, negative affect before the learning phase predicted a decrease in transfer, but only for the control condition. This effect is not attributable to the induction of positive and negative affective states because these participants saw an affectively neutral film clip. Nevertheless, the effect was statistically and practically meaningful. As shown in chapter 3.1.3.1, participants in the control condition did not differ in positive or negative affect as well as achievement goal orientations before watching the film clip compared the both of the other conditions. It is therefore not assumed that these findings were caused by differences between the subsamples. In fact, participants in the control condition probably represented the learner's typical affect in an achievement situation. The present results therefore indicate that in typical learning situations, differences in the learners' negative affective states can influence transfer performance. Specifically, the higher the negative affect before learning, the worse the performance in transfer. Inducing positive and negative affective states somehow compensated these declines in performance because neither the PA nor the NA condition was affected. For the PA condition, it is assumed that positive activating affect was induced by the positive film clip and may have balanced out this impairment. In contrast, participants in the NA condition reported higher levels of negative affect after the film clip. High levels of negative affect may have prevented these participants from performing better. Yet, this does not sufficiently explain why the NA condition did not perform worse on average level.

To sum up, inducing positive activating affect did not enhance learning outcome in terms of knowledge and transfer, while eliciting negative activating effect slightly impaired knowledge. Moreover, participants whose positive and negative affect was not manipulated performed worse in transfer, when experiencing higher levels of negative affect. As for negative affective states, the present results indicate that high levels can be detrimental for learning. This is in line with former findings (Ellis et al., 1984; Hembree, 1988; Pekrun et al., 2009), which is why it should be avoided to induce negative affect while learning.

There are several potential reasons why the prediction that positive activating affect is beneficial for learning was not supported. First, affective states decreased in all groups while learning, that is, reports of positive affect were lower after learning than before regardless of group membership. It is therefore not certain, that the affect induction was successful for the whole time of learning. Accordingly, learning enhancing effects of positive affective states might not have been present for the whole period of learning or worse, they might have decreased rather quickly. When comparing different affect induction procedures, Isen and Gorgoglione (1983) considered film clips as resulting in relatively persisting affective states. While other procedures lasted only for the manipulation check that typically follows immediately after the induction procedure, the effects of film clips in this experiment were still found after a short cognitive task. However, the cognitive task in Isen's and Gorgoglione's study took about 4 minutes, longer time spans were not examined. It therefore remains unclear whether affective states that were induced before an achievement situation maintain stable for longer periods of learning. Second, learning-related affective states are highly context-specific. According to Pekrun's (2006) control-value theory, affective states that are related to achievement or learning occur depending on the learners appraisals of control and subjective value of the learning situation. Watching humorous or disturbing film clips on the other hand might not have been contextually linked with learning or achievement situations as appraisals of perceived control and value were not specifically altered. It is therefore possible that the affective states that were induced in Experiment 1 did not completely relate to the learning context. Gross (1998) addresses a similar problem by stating that affective states induced by film clips do not generally relate to one-self, but can rather express subjective feelings towards the protagonists of the stimulus. In contrast, 'real' emotions (see Feldman Barrett, 2012 for a conceptual discourse) are highly self-relevant and tend to be stronger in intensity, longer in duration and do not necessarily need external stimuli to be induced. They can be induced for example by remembering live events that were affectively charged. Taken together, the present experiment succeeded in inducing affective states by the help of film clips. Given the nature of the learning-related affective states, there still can be no assurance that the film clips really induced learning-specific and self-relevant affect, which may have influenced learning performance in a greater extent. In fact, it is possible that the present data does not completely fit to the assumptions due to these considerations. Future studies should address this issue by using an induction procedure that can satisfy the recommendations more sufficiently.

Achievement motivation. Achievement goal orientations, which are linked to positive and negative affect, did not differ much between the groups during the experiment and therefore were not supposed to mediate the findings. According to the cognitive affective theory of learning with multimedia (CATLM; Moreno, 2005; Moreno & Mayer, 2007) positive affect should have positively influenced achievement motivation which in turn could have improved learning performance. Although mastery goal orientation slightly increased on descriptive levels in the PA condition while learning, the predictions of the CATLM could not be confirmed, specifically, there was no significant impact of increased mastery goal orientation on performance in the PA condition. In fact, the rise in mastery goal orientation was not statistically significant and had only little practical relevance. This may have occurred because achievement goal orientations are rather stable among different achievement situations and therefore have not significantly changed by watching a short film clip. As a resulting rather methodological issue, the SELLMO's 5-point Likert-scale might not be sensitive enough to detect subtle changes in achievement goal orientations. Future studies should therefore use a more finely graded rating scale.

3.1.4.2 Conclusions of Experiment 1

The CATLM does not specify the mechanisms underlying the assumed relationships between affect, motivation, and performance. It is therefore difficult to find conceptual reasons why the present experiment found contradictory results concerning the relationship between positive activating affect and learning outcome. Given the relatively small number of experimental studies, this work nevertheless provides a substantial contribution in this field of research. The presented findings were contrary to assumptions derived from the resource allocation theory (Ellis & Ashbrook, 1988). According to this theory, affective states are detrimental for learning performance because they increase task irrelevant thinking that binds the learner’s cognitive resources. Consequently, these resources are unavailable for the actual learning task. The negative relationship between affect and learning outcome was supported by earlier findings showing that inducing affective states reduced memory retrieval and increased cognitive effort (e.g., Ellis et al., 1985; Seibert & Ellis, 1991). However, the present experiment found that inducing affective states while learning does not reduce learning performance in any case as it would be expected based on the cited studies. Inducing negative activating affect before learning decreased learning performance in the present experiment, but this decline was not found for positive activating affect. Thus, inducing positive affect somehow may have positive effects while learning, as it was found frequently in other studies. Hence, the declines in learning performance predicted in the resource allocation theory may not be applicable for positive activating affect in academic settings. However, the findings of the present experiment indicate that positive affect is not detrimental for learning. Nevertheless, while negative activating affect seemed to reduce learning performance, the assumption of positive affect to improve learning was not met. This might be a result of the assumption that the affect induction did not elicit learning related and self-relevant affective states. Experiment 2 will therefore introduce an affect induction method that meets the requirements for the study’s aims more satisfactorily. More particular, Experiment 2 will use an affect induction intervention that induces self-relevant positive affect, which is related more closely to learning and achievement situations in order to further elaborate the role of affective states during learning. Moreover, because results in Experiment 1 concerning positive affective states are less clear, Experiment 2 will focus on the influence of these affects.

3.2 Experiment 2: Inducing Positive Activating Affect while Learning

3.2.1 Extended Theoretical Background of Experiment 2

Results of Experiment 1 were contrary to the assumptions derived from the resource allocation theory (Ellis & Ashbrook, 1988). Specifically, affective states must not necessarily be considered as being detrimental for learning under all circumstances. While negative activating affect tended to decrease learning performance, results for positive activating affect did not meet the assumptions of Ellis and Ashbrook. Based on these and previous findings that indicate that negative affect impairs learning outcome, it is recommended to avoid negative affective states in academic settings. Experiment 2 therefore refrains from examining the influence of negative affect on learning outcomes. However, Um and colleagues (2012) propose that positive affect while learning can enhance learning outcome in terms of performance and achievement motivation in their emotions as facilitator of learning hypothesis. The authors developed this hypothesis as an antithesis for assumptions based on the resource allocation theory and derivates of Sweller's (2005) cognitive load theory (CLT). Um and colleagues (2012) argued that affective states induced by the learning material can be interpreted as a possible source of extraneous cognitive load according to the basic concepts of the CLT. However, Sweller did not specifically mention these relationships between affective states and cognitive load. Um and colleagues (2012) further referred to studies on the coherence effect and research on the seductive details effect that indicated that adding elements that are interesting but not necessary for understanding the content of a text decrease a learner’s comprehension of the text’s key aspects (e.g., Garner, Brown, Sanders, & Menke, 1992; Harp & Mayer, 1998; Sanchez & Wiley, 2006).

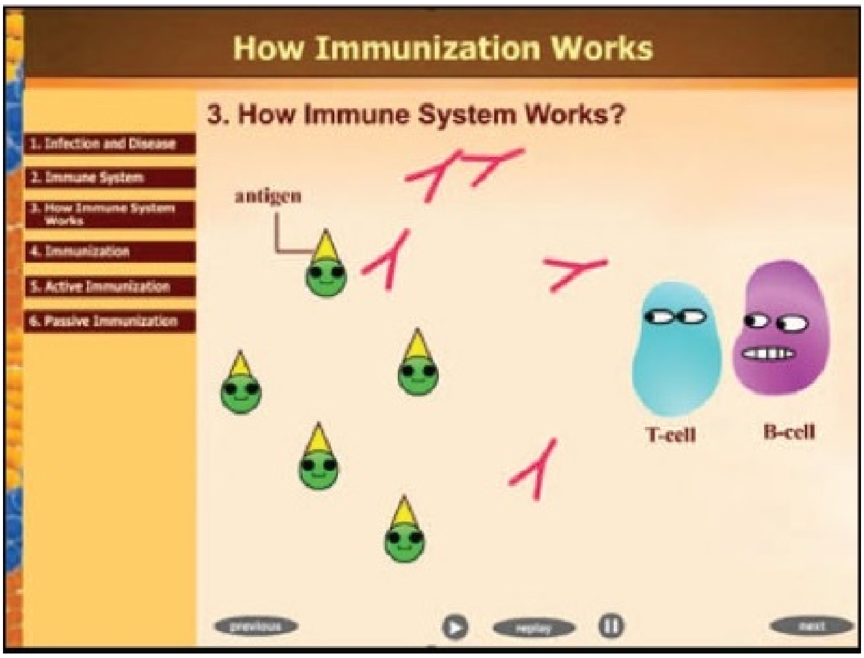

Figure 3.6. Multimedia learning environment designed to induce positive affect in Um et al. (2012, p. 489).

To examine this “affect as extraneous cognitive load” hypothesis (Um et al., 2012, p. 3) in multimedia learning settings, Um et al. (2012) induced positive affect directly while learning by using warm (specifically bright and saturated) colours and round anthropomorphic figures as design elements of a multimedia learning environment (see Figure 3.6). The results showed that inducing positive affective states permanently during a learning phase did not only protect against declines in learning performance predicted by the extraneous load hypothesis, the treatment actually resulted in higher learning performance in terms of knowledge and transfer compared to an affectively neutral control condition. Moreover, eliciting positive affect directly during learning did not increase extraneous but rather germane cognitive load. Furthermore, intrinsic achievement motivation was enhanced. Hence, the findings did not support the idea that positive affect during learning enhances extraneous cognitive load. This experiment therefore gives initial evidence that positive activating affect can be induced directly via the design of the learning material and that these affective states can promote learning outcomes.

Um et al.'s (2012) innovative contributions to the field provoked several authors to replicate and extend the study's results. However, these studies did not develop a coherent view on the role of positive affective states while learning. Subsequent works by Plass and colleagues (2014) as well as Park, Knörzer, Plass, & Brünken (2015) were not able to fully replicate the findings of Um et al. (2012) although exactly the same materials were used. While Plass et al. (2014) reproduced the effects of the affect induction procedure at least in one out of two studies, effects on learning performance were rather heterogeneous. In a first study, the authors did not find learning gains for transfer, which was contrary to the original study. Unlike in previous attempts, results of a second study in the same publication that used the same procedure as before found that warm colours had no effect on the learners' positive affect. Results on the induction of positive affect while learning using an emotional design procedure were therefore not completely coherent to Um et al.'s (2012) findings. Unfortunately, Plass et al. (2014) did not coherently report means and standard deviations as well as *p*-values and measures of effect sizes for each of the analyses. Given the small sample size of the study[9] the absence of effect sizes is especially questionable for the analysis to control for group differences in positive affect prior to the affect induction. In fact, calculating the required sample size using G*Power 3.1 (Faul et al., 2009) showed that a total of 180 participants would have been required in order to obtain a medium effect given an error probability of 5% and a statistical power of .8. However, related means of two of

[9] Although sample sizes are not reported for each of the four groups, the total sample size of 103 participants suggests that there could not have been more than 26 learners per group.

the four groups were higher on a visual level (see Figure 3.7 from Plass et al., 2014, p. 136).

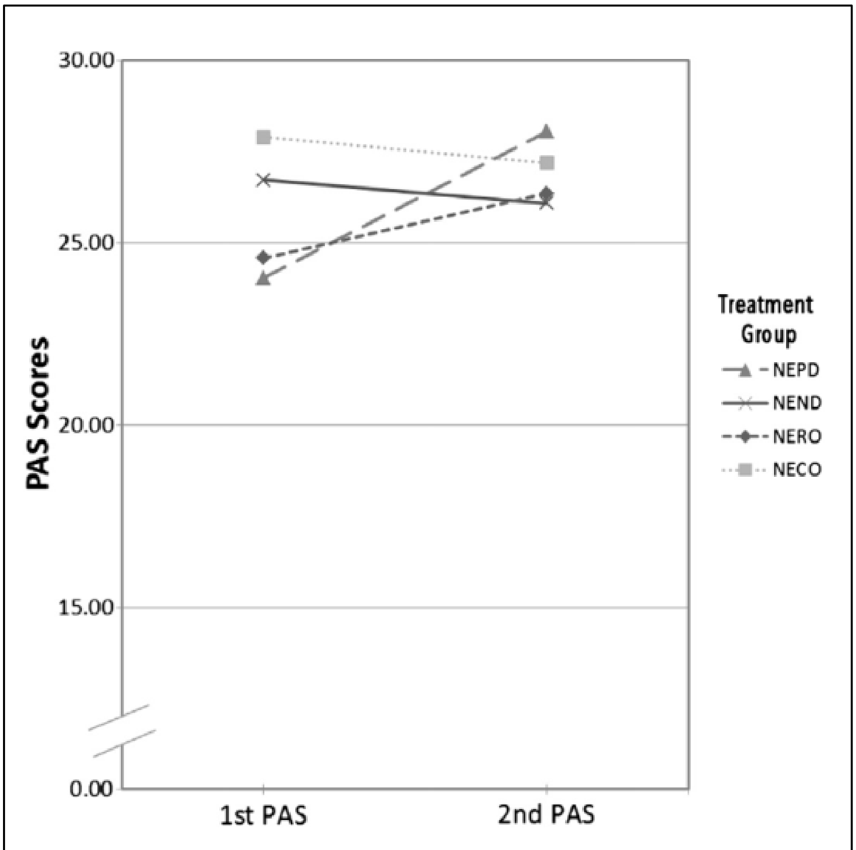

Figure 3.7. Visualization of the change in positive affect before and after learning in Plass et al. (2014, p. 136).

The authors have controlled for group differences and have found no significant difference. Yet, no effect size was reported. As argued earlier, small sample size can undermine inferential *F*-statistics crucially, therefore it is recommended to additionally report measures of effect size. Moreover, the effects on learning performance were also quite diverse in Plass et al.'s (2014) studies. While a combination of colour and shapes influenced the comprehension of the learning material, transfer was unaffected; yet transfer increased when only the figures' shapes were varied. For motivational scores, learner who received the combination of colour and shape and those who's learning environment was designed only with warm colours showed higher means, at least on descriptive levels[10].

Contrary to Plass's et al.'s (2014) study, Park et al. (2015) did not find that anthropomorphic design elements increase positive activating affect using the same materials as in Plass's studies. However, they found an increase in positive affect for the control condition that did not receive any affect induction at all. According to the authors, these unexpected findings were obtained because of a weak affect induction intervention and restricted variance in the reported affective states. Mayer and Estrella (2014) also tried to replicate the findings from Um et al. (2012) for the first time outside the laboratory of the research group alongside Jan Plass. In two studies, the authors found evidence for an emotional design procedure similar to the one introduced by Um et al. (2012) enhancing learning performance. Yet, their intervention also failed in inducing positive affective states since there were no differences in ratings of learning enjoyment between the treatment group and a control condition. Finally, there are rare findings that go in the opposite direction. For example, Knörzer and colleagues (2016) found that induced negative deactivating affects like sadness increased learning outcomes in terms of retention, comprehension, and transfer while inducing positive activating affect caused learning impairments. The authors thereby elicited positive activating affect differently using a combination of music and remembering affectively charged life events.

In sum, these findings draw a rather heterogeneous picture of the effectiveness of the emotional design affect induction during multimedia learning on the one side, and

[10] Unfortunately, the authors did not report p-values and measures of effect sizes for this calculation.

the influence of positive affect on learning outcomes on the other side. As Plass et al. (2014) themselves argued, an explanation for this result might be that anthropomorphic designs elements may cause better recall due to the figures' greater salience. The authors thereby qualify possible distortions in their studies because the figures' shapes should not have affected their concreteness. However, because salience might be confounded with positive affect when using this affect induction method. Therefore, a study is needed in which the learning material contains no anthropomorphic design elements. Furthermore, there might be situations in which face-like shapes cannot easily be implemented within a multimedia learning environment, especially when visualizations of the learning content do not involve anthropomorphic or figural elements (for example, the visual representation of electrical circuits) or when these visualizations do not allow changes in shape (e.g., the visualization of anatomical structures that have predetermined shapes). Hence, this experiment modifies the affect induction procedure of the previous experiments in such a way that anthropomorphic shapes are not used to induce positive affect.

3.2.2 Affect Induction using Colours and Shapes

As described in chapter 2.4, many of the more commonly used affect induction methods present affective stimuli either prior to the experimental task or before every block of trials. Both approaches may not be fully suitable for educational research studies if results of Experiment 1 are kept in mind. First, affective states vary in duration and intensity. Based on the conclusions of Experiment 1, it is difficult to ensure that pre-experimental induction methods are able to induce affective states that last for the whole period of learning. It is more likely that these affective states decrease or vanish after a short amount of time, that is, within several minutes. The general decrease in positive and negative affective states from before and after the learning phase in Experiment 1 supported these considerations. Learning on the other hand often continues for longer periods of time. Second, affective states are reciprocally linked and can instantly influence or elicit each other (Izard, 1972). According to Graesser and D'Mello (2012), different affective states occur throughout learning situations. These affective experiences therefore might interfere with the pre-experimental affect induction and compromise a successful emotion induction. Third, Gross (1998) and Feldman Barrett (2012) argued that real emotions arise in situations that are personally relevant for the individual, indicating an internal induction of affective states. As argued in chapter 3.1.4, affect that is induced via the use of film clips or pictures might instead be based on compassion with the protagonists and is therefore not fully relevant to the person. To test if affect influences the learning process and the learning outcome, self-relevant positive activating affect has to be induced for the full duration of the learning situation. Um et al. (2012) provide a promising induction method that meets these requirements. The authors used highly saturated and bright colours, such as yellow or orange, and round, anthropomorphic shapes as design elements in a multimedia learning environment and were able to induce positive affective states during learning. The use of colour and form for inducing positive activating affect is therefore discussed in further detail.

In the ecological valence theory of human colour preferences (EVT; Palmer & Schloss, 2010), it is argued that the colour of an object reveals information about its usefulness for the person and therefore causes approach or avoidance behaviour (e.g., red strawberries are preferred against green ones because the red colour signals the ripeness of the fruit). In other words, people are attracted to objects whose colours are associated with positive outcomes or advantages. These associations also appear to be highly context-specific (Elliot & Maier, 2007). Red, for instance, may elicit approach behaviour in the super market by signalling nutritious food. Contrary in learning contexts, where red is more likely associated with making mistakes or failing due to the use of red ink to mark errors (Elliot, Maier, Binser, Friedman, & Pekrun, 2009). However, colours do not only influence cognitive processes because of their hue but also because of their saturation and brightness (e.g., Taylor, Schloss, Palmer, & Franklin, 2013). Several studies by Palmer and his colleagues (Palmer & Schloss, 2010; Taylor et al., 2013) showed that people prefer light and highly saturated over dark or non-saturated colours. These colours have also been associated with positive affect in children (Boyatzis & Varghese, 1994) as well as college students (Hemphill, 1996).

Moreover, Palmer and Schloss (2010) showed that blue is generally the most preferred colour whereas brown is liked the least according to colour hues. Moreover, people generally prefer bright and saturated colours. However, the effect of a specific colour on human affect, cognition or motivation is highly context dependent. Although blue might generally evoke positive feelings, Mehta & Zhu (2009) state that blue is often associated with clear skies, water and tranquillity. This is in line with the assumption that the colours increasing wavelengths are positively correlated with increasing arousal indicating that red elicits high levels of arousal (e.g., Hamid & Newport, 1989; Stone & English, 1998). When used for inducing affective states while learning, colours of shorter wavelengths will probably elicit positive but deactivating affective states (like relaxation or calmness). These states are rather detrimental in complex learning situations, although Mehta and Zhu (2009) argued that blue could strengthen creativity. Nevertheless, it is not advisable to use blue for inducing positive activating affect in learning situations. Furthermore, because of its association with making mistakes and failing in achievement situations, it is neither recommended to use the colour red to induce positive affective states (although this hue may elicit high arousal). In contrast, colours like orange and yellow are fairly positively connoted (Palmer & Schloss, 2010) and, because of their higher wavelengths, should elicit activating rather than deactivating affective states (Stone & English, 1998). Bearing in mind that bright and saturated colours are associated with positive affective states, the use of bright and highly saturated colours of higher wavelengths such as orange or yellow should therefore elicit positive activating affect.

Several studies also indicated that the shape of design elements might influence affective perceptions. Kim, Lee, and Choi (2003), for example, found that the use of circled shapes in hypermedia environments predicted positive activating feelings such as strength and powerfulness. Other studies indicated that positive affect can be elicited by round and human-like shapes (e.g., Berry & McArthur, 1985; Plass et al., 2014). Nevertheless, there are serious constraints concerning the use of anthropomorphic or baby face-like shapes as an affect induction method in multimedia learning. First, there are findings that these shapes are strongly connected to capturing attention (Dehn & van Mulken, 2000). Therefore, learning material that contains anthropomorphic elements may simplify the acquisition of the information not only by eliciting positive affective states but also because these figures are more conspicuous to the learner. Second, the implementation of human-like shapes is only possible if the shaped elements do not require a specific form by themselves. If, for example, the learning content is about human anatomical structures, variations in the shape of the visualizations might impair learning outcomes by distorting the accuracy of the content. Additionally, although

Plass et al. (2014) found some evidence that altering shape alone might be sufficient to induce positive affect, variation of the figures in terms of round shapes on the one hand and baby-like faces on the other has not been examined separately. As mentioned above, it is at least conceivable that baby faces are connected to directing attention rather than eliciting positive affect.

3.2.3 Research Questions and Hypotheses of Experiment 2

Based on the results of Experiment 1, Experiment 2 aimed to further investigate the role of positive activating affect during multimedia learning. As described in chapter 2.2 and generally in line with assumptions from the resource allocation theory (Ellis & Ashbrook, 1988), negative activating affect is supposed to obstruct the learning process. In contrast, positive affect was hypothesized to increase learning outcome due to positive influences on learning related processes. According to Experiment 1, predictions from the resource allocation theory turned out not to be true for positive affect as learning performance was not decreased. Experiment 1 nevertheless failed in achieving learning gains caused by the positive affect induction as initially predicted. In section 3.1.4 it was discussed that the induction procedure using short film-clips might not have been suitable or persisting enough to induce learning related and self-relevant affective states. Therefore, Experiment 2 adopted the research design used in recent studies of the research group of Plass and colleagues who evoked positive activating affect while learning that turned out to positively influence the learning process using an emotional design approach. This procedure is supposed to induce self-relevant affect because it does not refer to or focuses on other human beings. Moreover, due to the maintenance of the affect induction over the entire period of learning, affective states should be induced throughout the entire learning situation. Although these results were very promising, studies so far do not draw a homogeneous picture of the effectiveness of this specific affect induction procedure and the role of positive affect on learning outcome in general (cf. Knörzer et al., 2016). Experiment 2 therefore had two main objects: First, results from Experiment 1 on the influence of positive activating affect while learning should be examined in more detail using a more learning-related affect induction. Second, previous findings on emotional designing should be extended in order to enhance learning outcome using another sample as well varied materials. To ensure a certain degree of generalizability of obtained findings, studies conducted by multiple researchers using different samples and materials are mandatory. As argued earlier, the positive affect induction procedure should not affect negative activating affect due to the orthogonal structure of positive and negative affective states. It is therefore hypothesized that:

H1a – Learning with a multimedia learning environment that uses bright and saturated colours and round edges increases levels of positive activating affect during learning compared to a control condition.

H1b – Learning with a multimedia learning environment that uses bright and saturated colours and round edges does not alter levels of negative activating affect during learning compared to a control condition.

Results of Experiment 1 regarding the influence of positive activating affect on learning outcome did not met the assumptions, that is, inducing positive activating affect before learning did not increase learning outcomes. Experiment 2 nevertheless supports this assumption because of several reasons: First, the findings of Experiment 1 did not reveal contradicting results in terms of positive activating affect being detrimental for learning as the opposing theoretical views would suggest (i.e. the resource allocation theory). Second, there are concerns about Experiment 1's affect induction procedure that may have not induced long lasting, self-relevant, and learning-associated affective states but rather positive respectively negative feelings towards the protagonists seen in the film clips. Finally, there is still evidence for the emotions as facilitator of learning assumption (Um et al., 2012) in general and, with some restrictions, for the emotional design approach (see section 3.2.1). Similar to Experiment 1, it is therefore assumed that:

H2a – Participants who learn with a multimedia learning environment that uses warm colours and round edges perform better in knowledge compared to a control condition.

H2b – Participants who learn with a multimedia learning environment that uses warm colours and round edges perform better in transfer compared to a control condition.

Further results of Experiment 1 showed that achievement goals were not altered throughout the learning process by inducing positive and negative activating affect. However, mastery goal orientation tended to increase when positive affect was induced before the learning phase. This is in generally in line with the assumptions of the cognitive affective theory of learning with multimedia (e.g., Moreno, 2006). Moreover, when using an emotional design approach to foster learning outcome higher levels of achievement motivation for learner under the positive affect condition were reported (e.g., Um et al., 2012). As mentioned earlier, emotional design principles are meant to induce learning-related affective states more likely than presenting film clips. It is therefore assumable that this affect induction should influence achievement goals stronger. According to numerous studies and based on the results of Experiment 1, positive affect is positively correlated with higher levels of mastery goals as well as performance approach goals whereas correlations between positive affect and performance avoidance goals are usually negative (see Huang, 2011). Hence, it is further expected:

H3a – Learning with a multimedia learning environment that uses warm colours and round edges increases levels of mastery goal orientation during learning compared to a control condition.

H3b – Learning with a multimedia learning environment that uses warm colours and round edges increases levels of performance approach goal orientation during learning compared to a control condition.

H3c – Learning with a multimedia learning environment that uses warm colours and round edges decreases levels of performance avoidance goal orientation during learning compared to a control condition.

To sum up, one's affective experiences while learning are supposed to be strongly connected to learning-relevant cognitive processes and have been investigated in numerous studies (see Pekrun & Stephens, 2011, for a review). Positive activating affect has been found to enhance learning outcome in multimedia learning (Plass et al., 2014; Um et al., 2012). Hence, the present experiment aimed to induce positive activating affect using an emotional design approach and tested its beneficial effects on learning outcomes.

3.2.4 Methods of Experiment 2

Experiment 2 used some of the materials that were employed in Experiment 1, descriptions of reused materials are therefore written rather briefly in order to reduce redundancy. Materials and instruments can be found in the appendix.

3.2.4.1 Sample and Design of Experiment 2

A total of 118 undergraduate students from a German university took part in Experiment 2. All participants were German native speakers and registered with an online recruitment system for experiment participation used by the university and voluntarily chose to participate in the experiment after being invited via e-mail. Similar to Experiment 1, the participants selected one out of several time slots to be tested. Participants were tested in groups of up to 20 people; group size varied based on students' preference for the available time slots. Each group of participants (i.e., each time slot) was randomly assigned to one of two conditions: Participants in the positive affect (PA) condition had to learn in a multimedia environment that was designed to induce positive activating affect, whereas participants in the control condition (CG) learned in an affectively neutral environment. Affective states and achievement goal orientations were measured before (t1) and after the learning phase (t2). Because the participants were not aware of the different experimental conditions when registering, it is assumed that the person's personality traits did not systematically interact with the choice of a specific time slot. Four of the 118 participants were excluded from all analyses because they were highly familiar with the learning topic. Three students were excluded because they failed to give an appropriate code number to match the questionnaires from pre- to post-test. The average age of the remaining 111 participants was 20.2 years (*SD* = 1.8; ranging from 18 to 27 years). Eighty-eight (79.3%) of the students were female. Most of the participants (100, 90.1%) were studying media communication; the others were studying human computer interaction. The average study time was 2.0 (*SD* = 1.0) semesters, meaning that most of the students were at the beginning of their studies. In sum, 61 (55%) participants were in the PA condition, and

50 (45%) were in the CG condition. Each participant was rewarded with two hours of partial course credit.

3.2.4.2 Materials used in Experiment 2

Design of the Learning Environment. The learning material was used to manipulate affect through the use of different colours and shapes. It consisted of two sets of multimedia-based pages (one for each condition) on the subject of ‘functional neuroanatomy’ written in German using HTML 5. Both sets of nodes were constructed identically and contained the same learning text as well as the same navigation opportunities as the learning environment in Experiment 1. To present the hypertext environment the Mozilla Firefox version 17.0 browser (Mozilla Project, 2012) was used. Figure 3.8 shows examples of both learning environments. As in Experiment 1, the background and the images in the control condition were monochromatic, that is, different shades of grey were used. Moreover, the images in the control condition were framed with rectangular shapes. In contrast, the PA condition was designed using warm colours (bright and highly saturated) such as yellow or orange in the background and within the images. In addition, all images were framed in round shapes. As stated in section 3.2.1, anthropomorphically shaped figures, which were used in previous studies, are not always useful for illustrating educational material. For this reason, and to avoid confounding effects with attentional processes, the present experiment did not use this feature to induce affect. It was assumed that these manipulations would induce a positive activating affect during learning in the PA condition without influencing the difficulty of the learning content. By varying the learning material between the two conditions only as much as necessary, it was also ensured that there were no confounding effects caused by differences in perceptional features such as salience.

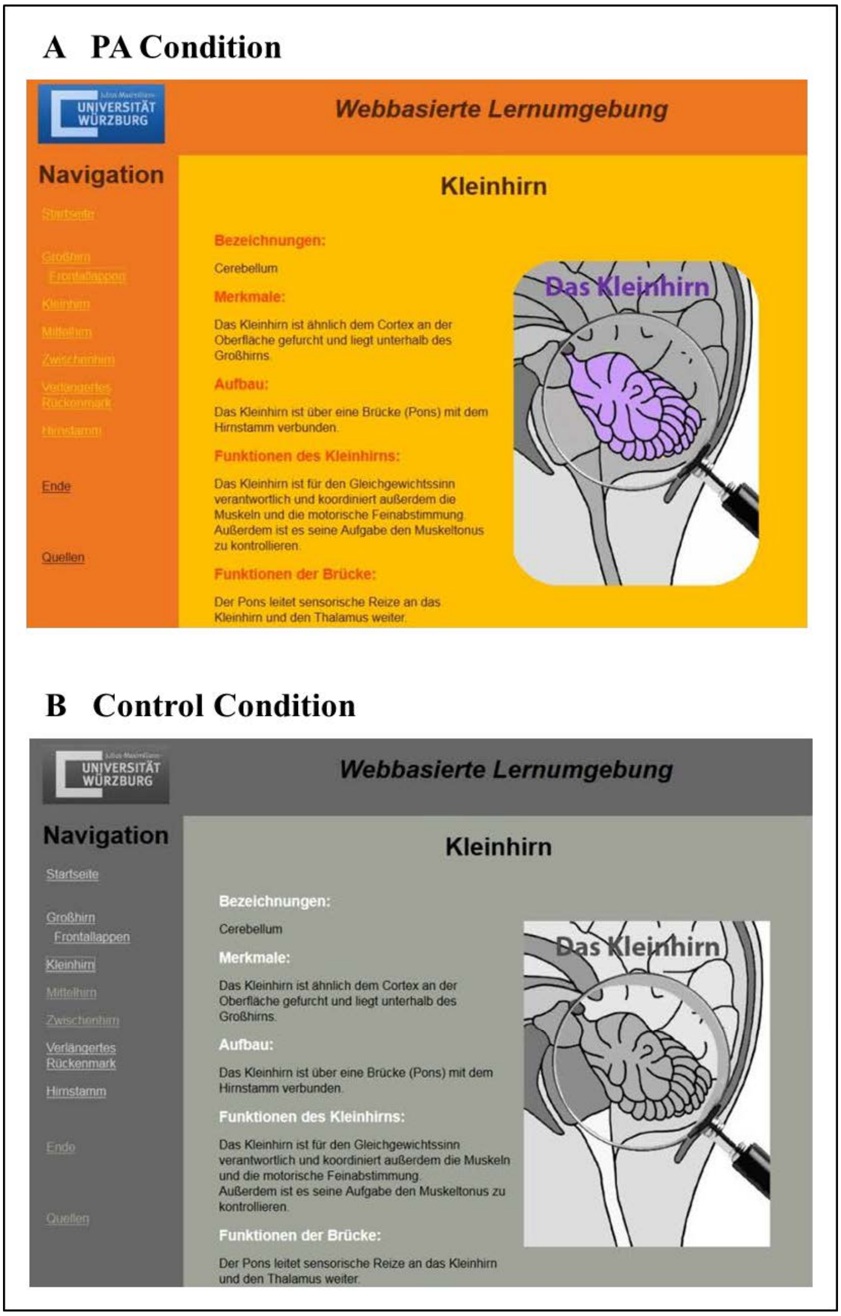

Figure 3.8. Screenshots of the two multimedia learning environments used in Experiment 2. (A) the learning environment designed to elicit positive affect by the use of bright colours and round shape, (B) affectively neutral counterpart using achromatic colours and sharp edges.

3.2.4.3 Measures used in Experiment 2

Self-Assessed Prior Knowledge. Prior knowledge was assessed as in Experiment 1 by asking for the participants' familiarity with the learning topic. Participants who did not report that the topic was completely unknown to them were excluded from further analyses. As mentioned already above, this was the case for four participants in Experiment 2.

Activating Affect. Experiment 2 also used the German version of the Positive and Negative Affect Schedule (PANAS; Krohne et al., 1996) to measure positive and negative activating affect. In Experiment 2, the original 5-point Likert-scale was replaced by a visual analogue scale ranging from 0 = 'not at all' to 100 = 'completely'. These scales have proven to be sensitive even to small changes in affective states (Joyce, Zutshi, Hrubes, & Mason, 1975). According to Reips and Funke (2008), using visual analogue scales meets the requirements for data on interval level most suitable. Similar to Experiment 1, internal consistencies of the measurement of affective states before and after the learning phase were all satisfactory with a minimum of Cronbach's α = .84 (see Table 3.9). Therefore, changes in the response format did not negatively influence the reliability of the PANAS.

Achievement Motivation. As in Experiment 1, achievement goal orientations were measured as indicators of achievement motivation. Results of Experiment 1 showed that goal orientations did not vary strongly. However, strong changes in goal orientations are not very likely in concrete learning situations because of the trait-like character of the construct. To be able to assess small changes in goal orientations regardless of this limitation, Experiment 2 used an adapted version of the SELLMO self-report questionnaire (Spinath et al., 2002) that was deployed in Experiment 1. The original item stem of the SELLMO's student version was altered from 'For me, studies are about …' to 'At the moment, I want to …' in order to enable a more state-like measurement. Moreover, several items were changed (e.g., '… showing that I am good at something' was changed to '… showing that I am good at this task') or excluded (e.g., '… to do not have any hard exams.’). Finally, similar to Experiment 1, the SELLMO’s work avoidance subscale was discarded. In the end, the adapted version of the SELLMO used in Experiment 2 consisted of 19 items. Analogous to measuring affect, visual analogue scales ranging from 0 = ‘not at all’ to 100 = ’perfectly’ instead of a Likert-scale were used. Internal consistencies were calculated and showed satisfactorily results with a minimum value for Cronbach’s α of .81 (see Table 3.9). This indicated that the adaption of the SELLMO to measure state instead of trait achievement motivation as well as changing the response format did not have negative consequences on test reliability.

Table 3.9

Descriptive Statistics of the Variables in Experiment 2 for the Full Sample (N = 111)

	Number of items	Min[a]	Max[a]	*M*	*SD*	Internal consistencies[b]
Positive affect						
t1	10	32.95	83.55	66.48	9.06	.84
t2	10	28.50	94.30	65.32	10.68	.90
Negative affect						
t1	10	0.00	55.30	11.52	15.23	.85
t2	10	0.00	67.80	12.25	11.25	.88
Mastery goal orientation						
t1	7	16.29	91.86	52.91	17.09	.82
t2	7	8.57	89.43	48.95	18.36	.87
Performance approach goal orientation						
t1	5	9.34	97.60	48.12	18.70	.81
t2	5	7.67	100.00	44.62	21.22	.86
Performance avoidance goal orientation						
t1	7	7.34	91.71	41.83	22.97	.91
t2	7	13.45	90.01	39.20	25.40	.95
Performance						
Knowledge	12	.34	.94	.56	.17	.61
Transfer	2	1.00	3.00	2.11	.55	.81[c]

Note. t1 = before the learning phase; t2 = after the learning phase; [a] Using visual analogue scales from 0 – 100 except for performance indicators; [b] Cronbach’s alpha; [c] Interrater reliability Cohen’s kappa

Learning Outcomes. Learning outcome was measured analogous to Experiment 1. In fact, the same 12 single choice items to assess knowledge and two open questions for transfer were used. The total scores were set as indicators of learning performance. Internal consistency for knowledge was acceptable (α = .61, see Table 3.9). To assess the inter-rater reliability of transfer scores, Cohen's kappa was calculated based on the scores of 20 randomly selected participants who were rated independently by two trained student assistants ($\kappa = .81$). Based on the guidelines from Altmann (1999), inter-rater reliability was substantial for the subsample.

3.2.4.4 Procedure of Experiment 2

This experiment's procedure was quite similar to Experiment 1. After being welcomed by the experimenter, participants were informed about the upcoming tasks. To mask the aim of the experiment, they were further told that the experiment was about a test for a hypertext environment that had been designed based on the participants' demographic characteristics. Participants were seated in front of a computer and asked to follow the instructions presented on the screen. As in Experiment 1, demographic variables, the participant's estimation of their prior knowledge, and initial affect as well as achievement goal orientations were assessed first. Afterwards, the participants were asked to learn for 20 minutes in either the PA or control condition ("Please work with the learning material for the next 20 minutes and try to memorize as much of the presented content as possible"). During that time, all participants were free to navigate within in the learning environment. After the learning phase, learning outcome and the post-experimental affect and goal orientations were measured. Finally, the experimenters thanked the participants and explained the purpose of the experiment if desired. Analogous to Experiment 1, Experiment 2 was about 60 minutes in time. As before, SoSci Survey (Leiner, 2014) was used to administer all of the questionnaires and the performance test. Figure 3.9 shows the procedure of Experiment 2.

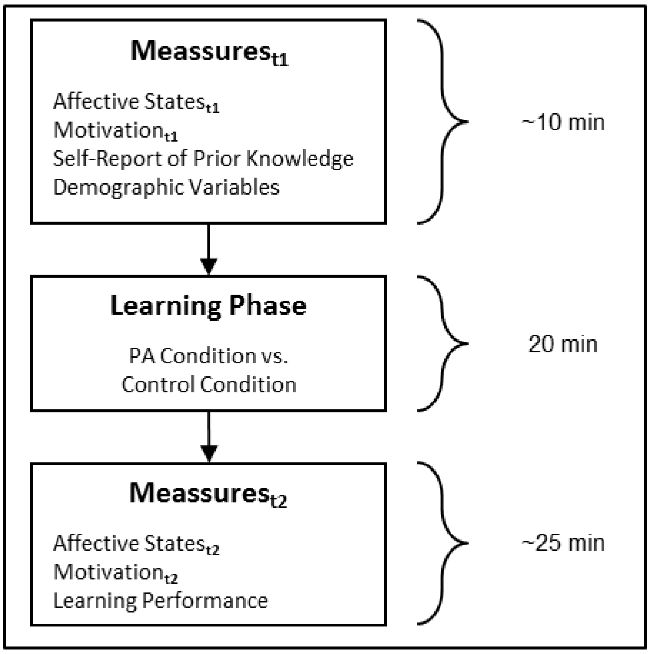

Figure 3.9. Procedure of Experiment 2.

3.2.5 Results of Experiment 2

Analogous to Experiment 1, all of the analyses were conducted with IBM SPSS Statistics 22 software and the significance level was set at 5%, unless noted otherwise. Again, all of the assumptions to conduct the inferential statistical test procedures were checked and had been fulfilled if not otherwise stated. At first, it was checked if there were differences in any of the control variables between the two groups before the learning phase in order to exclude possible confoundings in the dependent variables. Next, it was checked if the manipulation of positive activating affect had worked in the PA condition. For hypotheses testing, differences in learning outcome and the change of achievement motivation were compared between the PA and control condition.

Similar to the data analyses in Experiment 1, a regression approach was used in order to include covariates as predictors in the regression and test if they are appropriate, that is, if they have the same impact on the dependent variable for both groups (see Cohen et al., 2003; Hayes, 2013). Because results concerning achievement goal orientation and affective states revealed an unexpected interaction effect in Experiment 1, Experiment 2 continued this line of analyses by also calculating regions of significance for significant interaction effects. Specifically, varying levels of the continuous moderating predictors in which there were differences between conditions in the dependent variable were calculated. It was further checked how many of the participants had values within these regions. Again, the distribution of the externally studentized residuals for each regression analysis was checked using scatterplots, histograms, and Q-Q plots in order to ensure that the assumptions for regression analysis were met. It was further controlled for collinearity.

3.2.5.1 Preliminary Analyses of Experiment 2

Descriptive Analyses. Descriptive statistics and reliability scores for all variables assessed in Experiment 2 are displayed in Table 3.9. Similar to Experiment 1, most of the scales were highly reliable. However, the internal consistency for the knowledge test was lower than in Experiment 1 but sufficient for research purposes. As in Experiment 1, reported levels of negative activating affect were quite low compared to the scores in positive activating affect. Again, participants did not use the full range of the scale provided in order to rate their negative affect. However, it is unlikely that there were any distortions due to variance restrictions because the standard deviations of negative affect scores were bigger than those of positive affect scores. Levels of achievement goal orientation did not differ greatly between the three subscales. Furthermore, there were only subtle changes between measurements from t1 and t2. The biggest changes were found for mastery as well as performance approach goal orientation. For both scales, test scores decreased from t1 to t2 about approximately four scale points. However, when considering that the visual analogue scales ranged from zero to one hundred, drops of four scale points may not indicate significant differences. Nonetheless, inference statistical analyses were done in order to check for these effects. For learning performance, scores were comparable to those in Experiment 1 that had used the same materials. Although three participants achieved the maximum attainable points in the transfer test, there was no sign of ceiling effects for the whole sample.

Correlational Analyses. Pearson correlations between pre- and post-measures of affective states and achievement goal orientations as well as performance can be found in Table 3.10. Highly positive correlations were found for positive affect at t1 (before the learning phase) and t2 (after the learning phase) as well as for negative affect at t1 and t2. However, contrary to the correlations in Experiment 1, reported levels of positive and negative activating affect were correlated negatively. According to the circumplex model proposed by Watson and Tellegen (1985), positive and negative affect should be independent from each other. Nonetheless, these findings indicate that high levels in positive affect are associated with low levels in negative affect, and vice versa. Accordingly, it is advised to check for unexpected moderation effects between positive and negative affect when testing for hypotheses. In accordance with the scientific literature (e.g., Huang, 2011) as well as with the correlations found in Experiment 1, positive activating affect was positively correlated with mastery goal orientation goal orientation across all measurements. Contrary to Experiment 1, there were no significant correlations between positive affect and performance approach goal orientation except for t2. On the other hand, negative affective states were correlated positively with both types of performance goal orientation. Hence, correlations between affective states and motivational variables in Experiment 2 were generally as expected and in line with previous findings.

Table 3.10

Summary of Pearson Correlations between the Measures in Experiment 2 (N = 111)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Positive affect											
1. t1											
2. t2	.73**										
Negative affect											
3. t1	-.62**	-.45**									
4. t2	-.48**	-.65**	.78**								
Mastery goal orientation											
5. t1	.30**	.28**	.17	.16							
6. t2	.29**	.38**	.12	.13	.79**						
Performance approach goal orientation											
7. t1	.08	.07	.28**	.24*	.54**	.44**					
8. t2	.15	.19*	.19*	.18	.44**	.53**	.75**				
Performance avoidance goal orientation											
9. t1	-.04	-.14	.37**	.41**	.41**	.32**	.67**	.60**			
10. t2	-.07	-.18	.32**	.37**	.31**	.28**	.63**	.68**	.37**		
Performance											
11. Knowledge	.31**	.38**	-.22*	-.22*	.22*	.34**	.10	.28**	-.01	.06	
12. Transfer	.20*	.33**	-.18*	-.30**	.28**	.20*	.02	.01	.04	-.14	.28*

Note. t1 = before the learning phase; t2 = after the learning phase; * < .05, ** < .01

In addition, reported levels of positive affective states were correlated positively with knowledge as well as transfer scores. The opposite occurred for negative affect, that is, negative affective states were correlated negatively with indicators of learning performance. The correlations concerning affective states and learning performance were different from those found in Experiment 1 but in line with this experiment's hypotheses.

Differences Prior to the Learning Phase. To exclude systematic distortions due to pre-experimental differences between the two conditions, a MANOVA with the initial positive affect and negative affect as dependent variables was calculated. Descriptive statistics are shown in Table 3.11. Using Pillai's Trace, the one-way MANOVA did not show any significant differences between the control and PA condition, $V = .02$, $F(2,108) = .82$, $p = .451$, $\eta_p^2 = .02$, which indicated that there were no systematic group differences in affect before the treatment occurred.

Another MANOVA was calculated with levels of goal orientations before learning as dependent variables in order to test for differences between the two groups (see Table 3.11 for descriptive statistics). Using Pillai's Trace, there were no significant differences between the control and PA condition, $V = .03$, $F(3,107) = 1.14$, $p = .336$, $\eta_p^2 = .03$. Hence, participants in the two conditions did not differ in levels of achievement goal orientation before the learning phase. Furthermore, the randomization for the demographic variables was checked. There were no significant differences between the conditions concerning the age of the participants, $t(109) = -.69$, $p = .490$, and the distribution of gender was the same for both conditions, $\chi 2(1, N = 111) = .03$, $p = .865$.

Table 3.11

Descriptive Statistics of Affective States and Goal Orientations Experiment 2 (N = 111)

	Number of items	CG (n=50)		PA condition (n=61)	
		M	*SD*	*M*	*SD*
Positive affect					
t1	10	65.38	9.07	67.39	9.03
t2	10	64.20	9.96	66.26	11.23
Negative affect					
t1	10	12.10	10.61	10.93	19.86
t2	10	12.31	10.98	12.19	11.51
Mastery goal orientation					
t1	7	50.30	17.37	55.05	16.69
t2	7	48.06	20.23	49.69	16.82
Performance approach goal orientation					
t1	5	45.69	20.67	50.12	16.81
t2	5	42.90	23.72	47.03	19.02
Performance avoidance goal orientation					
t1	7	41.48	23.74	42.12	22.52
t2	7	38.24	26.88	39.98	24.31

Note. PA = positive affect; t1 = before the learning phase; t2 = after the learning phase.

3.2.5.2 Hypotheses Testing of Experiment 2

Hypothesis 1 – Affect Induction. The first hypothesis in the present experiment was that participants learning in a learning environment that was designed using warm and saturated colours as well as rounded shapes should report higher levels of positive activating affect (Hypothesis 1a) compared to a control condition. Contrarily, levels of negative activating affect should not be altered by the design of the learning environment (Hypothesis 1b). To check if the treatment induced positive affect a mixed ANOVA with pre- and post-experimental positive affect as the within-person factor and condition as the between-person factor was conducted. The descriptive statistics can be found in Table 3.11. Results of the mixed ANOVA showed no significant interaction effect, $F(1,109) = .10$, $p = .747$, $\eta_p^2 < .01$, but a significant effect of time, indicating the decrease of positive affect during the learning phase for both groups, $F(1,109) = 4.41$, $p < .05$, $\eta_p^2 = .04$. Measures of effect size indicate a rather small effect. Accordingly, Hypothesis 1a had to be rejected, that is, the emotional design of the learning environment did not elicit positive activating affect. Concerning negative affect as the dependent variable, there was neither an increase nor a decrease in negative affect during the learning phase, $F(1,109) = .72$, $p = .397$, $\eta_p^2 = .01$, and no significant interaction of time and condition, $F(1,109) = .30$, $p = .584$, $\eta_p^2 = .00$. As expected in Hypothesis 1b, the emotional design if the learning environment did not affect negative activating affect in the experimental condition.

Further hypotheses of the present experiment suggest that positive affect during learning enhances learning outcome and achievement motivation. As there was no difference between the two conditions in the change of positive activating affect during the learning phase, these initial hypotheses seemed not very promising anymore. The initial hypotheses were tested regardless, due to two reasons: First, the subjective experience of affect that is reflected in the PANAS is only one component of affect (Scherer, 1984) and it might be that the treatment had an effect that is not reflected in the subjective experience. Second, there might have been unexpected interaction effects covering the effect of the treatment. Therefore, it was tested whether participants in the two conditions differed in performance and the change in goal orientation.

Hypothesis 2 –Learning Performance. In Hypotheses 2, it was assumed that participants in the PA condition outperform those in the CG in knowledge (Hypothesis 2a) as well as transfer (Hypothesis 2b). Table 3.12 shows means and standard deviations for knowledge as well as transfer. Conditions were dummy-coded, using the control condition as reference group. Analogues to Experiment 1, the hypotheses were tested in three steps: First, a regression of performance or achievement motivation on condition was calculated to test the hypothesis. Second, in order to exclude any unexpected influences of potential covariates (i.e., initial positive and negative affect), these variables were added to the regression model. Third, the interactions between condition and covariates were added to the model to test if the model was specified correctly, that is, if the covariates have the same effect on post-test performance for both conditions. If a significant interaction effect was found, the model with condition and covariates as the only predictors would not be appropriate: The interaction has to be taken into account. Finally, all non-significant predictors were removed from the model to minimize over-fitting. Thus, the model that explained the variance in the dependent variable best was described.

Table 3.12

Descriptive Statistics of Learning Performance in Experiment 2 (N = 111)

	Number of items	CG (n=50)		PA condition (n=61)	
		M	*SD*	*M*	*SD*
Learning performance					
Knowledge	12	.54	.18	.57	.16
Transfer	2	2.01	.71	2.21	.40

Hypothesis 2a - Affect and Knowledge. The results for the first model – condition-only model in Table 3.13 – showed that condition had no significant effect on knowledge of the learning material, $R^2 = .01$, $F(1,109) = .61$, $p = .437$, $f^2 = .01$. Therefore, the initial hypothesis about differences in knowledge of the learning content between conditions had to be rejected, at least without considering covariates. In the next step, initial positive and negative affects were added as covariates to the regression model, named the main effects model in Table 3.13. The variance that could be explained by the main effects model increased significantly compared to the condition-only model, $\Delta R^2 = .11$, $F(2,107) = 6.51$, $p < .01$, that is, the main effects model explained $R^2 = .11$ of the variance in knowledge, $F(3,107) = 4.56$, $p < .01$, $f^2 = .12$. An inspection of the regression coefficients (see Table 3.13) showed that pre-experimental positive affect significantly predicted knowledge and that pre-experimental negative affect predicted knowledge inversely.

Table 3.13

Regression of Knowledge on Condition, and Positive and Negative Affect measured before Learning in Experiment 2 (N = 111)

	Knowledge		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	6.480	22.24	< .001
Condition	.307	.78	.437
Main effects model			
Intercept	6.567	23.55	< .001
Condition	.149	.40	.693
Positive affect	.035	2.75	.007
Negative affect	-.038	-2.15	.034
Interaction model			
Intercept	6.633	24.11	< .001
Condition	.129	.35	.729
Positive affect	.049	2.51	.013
Negative affect	-.078	-2.98	.004
Condition x positive affect	-.027	-1.05	.297
Condition x negative affect	.074	2.12	.036
Final model			
Intercept	6.619	24.08	< .001
Condition	.133	.36	.721
Positive affect	.034	2.66	.009
Negative affect	-.081	-3.11	.002
Condition x negative affect	.077	2.22	.029
Condition x positive affect	---	---	---
Positive x negative affect	---	---	---

Note. Condition was dummy-coded using the neutral affect condition as the reference group. Positive and negative affect were centered. Dashes are indicating that the predictor was not entered into the regression model.

Thus, the more positive affect and the less negative affect before the learning phase, the better the students comprehend the learning content. To ensure that the covariates' slopes were the same for both conditions – this is a prerequisite of a covariate – the first order interactions between condition and positive affect and between condition and negative affect were added to the regression model as predictors. The increase in predictive power over the main effects model was not significant, $\Delta R^2 = .05$, $F(2,105) = 3.01$, $p = .053$, but nevertheless, the interaction between condition and negative affect showed a significant effect (see the interaction model in Table 3.13). To test for a misspecification of the model, it was also checked for the interaction between positive and negative affect and for the second order interaction of all three main predictors, but none of these interactions was significant. Finally, the non-significant interaction between condition and positive affect was deleted from the interaction model to reduce potential over-fitting. This final model explained significantly more variance than the main effects model, $\Delta R^2 = .04$, $F(1,106) = 4.92$, $p < .05$, and explained $R^2 = .15$ of the variance in knowledge, $F(4,106) = 4.78$, $p < .001$, $f^2 = .18$. As presented in Table 3.13, the condition had no significant main effect, but the main effects of positive and negative affect as well as the interaction between condition and negative affect were significant predictors of knowledge after learning. To interpret this final model, the regression lines of knowledge on negative affect were plotted for the control and PA conditions in Figure 3.10.

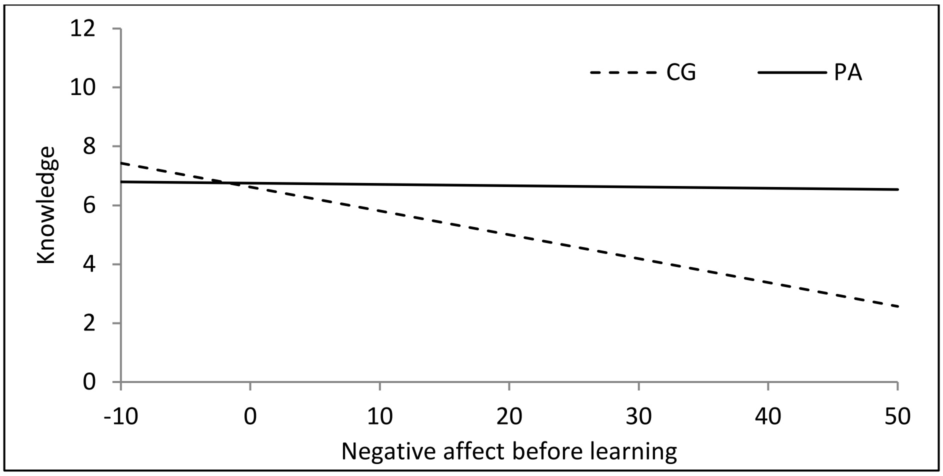

Figure 3.10. Regression of knowledge after the learning on negative affect for the control condition (CG) and the positive affect condition (PA) in Experiment 2. Negative affect was centered, positive affect was held constantly at the average value.

The simple slopes of knowledge on negative affect were $b = -.081$, $t = -3.11$, $p < .01$ for the control condition, and $b = -.004$, $t = -.19$, $p = .850$ for the PA condition. Therefore, negative affect predicted the knowledge of the learning material for students who learned with the material in the control condition, that is, the more negative affect before learning the less the students comprehended. Regions of significance for the differences between the conditions were calculated as described by Preacher, Curran, and Bauer (2006) using their website tool. For students with a centered pre-experimental negative affect in the interval [-32.5, 13.6], the difference in knowledge between the PA condition and the control condition was not significant. Outside this interval however, the difference was significant. As no student in the sample had values for pre-experimental negative affect in the lower region of significance]-∞, -32.5[, this region is not of much interest, and thus, this result is not interpreted any further. However, 11 students (9.9%) had a centered negative affect higher than 13.6 before learning, and thus, the region of significance]13.6, ∞[is worth interpreting, that is, for 9.9% of the students, the PA condition led to enhanced knowledge compared to the control condition. For those participants, Hypothesis 2a, that assumed that positive affect is beneficial for performance in knowledge, was true.

Hypothesis 2b - Affect and Transfer. Again, condition was dummy-coded with the control condition being the reference condition. In the first step, condition was used as the only predictor to test the hypothesis about the impact of the type of learning environment on learning outcome. The results are listed as the condition-only model in Table 3.14. Therefore, condition had no significant effect on transfer after the learning phase, $R^2 = .03$, $F(1,109) = 3.26$, $p = .074$, $f^2 = .03$, and thus, the hypothesis had to be rejected for transfer as well, at least if covariates were not taken into account. However, using initial negative and positive affect as covariates did not significantly improve the amount of explained variance, $\Delta R^2 = .04$, $F(2,107) = 2.34$, $p = .102$. Therefore, neither positive nor negative affect predicted transfer significantly (see the main effect model in Table 3.14).

Table 3.14

Regression of Transfer on Condition, and Positive and Negative Affect measured before Learning in Experiment 2 (N = 111)

	Transfer		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	4.020	25.11	< .001
Condition	.390	1.81	.074
Main effects model			
Intercept	4.051	25.50	< .001
Condition	.333	1.55	.124
Positive affect	.009	-1.17	.246
Negative affect	-.017	-1.74	.085
Interaction model			
Intercept	4.040	25.30	< .001
Condition	.336	1.56	.121
Positive affect	-.003	-.31	.760
Negative affect	-.019	-1.25	.216
Condition x positive affect	.021	1.38	.169
Condition x negative affect	.001	.07	.946
Final model			
Intercept	4.055	26.14	< .001
Condition	.330	1.58	.118
Positive affect	-.012	-1.01	.317
Negative affect	-.011	-1.03	.305
Condition x negative affect	---	---	---
Condition x positive affect	.032	2.11	.038
Positive x negative affect	.002	2.40	.018

Note. Condition was dummy-coded using the neutral affect condition as the reference group. Positive and negative affect were centered. Dashes are indicating that the predictor was not entered into the regression model.

As interaction effects may have hidden the influence of the predictors of transfer, interactions between condition and pre-experimental positive affect and between condition and pre-experimental negative affect were added to the regression analysis. However, the interaction model (see Table 3.14 for regression coefficients) did not significantly improve the amount of explained variance compared to the main effects model, $\Delta R^2 = .02$, $F(2,105) = .96$, $p = .387$, because none of the two interactions was significant. Finally, it was tested for the interaction of negative affect before the learning phase with positive affect before the learning phase and the second order interaction between condition, positive affect, and negative affect. This model significantly improved the amount of variance explained compared to the interaction model, $\Delta R^2 = .07$, $F(2,103) = 4.27$, $p = .017$. After removing the non-significant predictors from this last model in order to reduce over-fitting, the final model reported in Table 3.14 was built. This model explained $R^2 = .13$ of the variance, $F(5,105) = 3.24$, $p = .009$, $f^2 = .15$, and will be inspected in more detail next.

To interpret the results, regression lines for each condition were plotted (see Figure 3.11). For all levels of pre-experimental negative affect, there were significantly different slopes for the PA condition compared with the control condition. Thus, this interaction will be inspected only for an average level of initial negative affect in more detail (see Figure 3.11B). The simple slope for the control condition was not significant, $b = -.012$, $t = -1.01$, $p = .317$, but the simple slope for the PA condition was significant, $b = .021$, $t = 2.16$, $p < .05$; thus, the more positive the pre-experimental affect, the better were the students able to transfer the acquired content to new problems. The calculated region of significance for an average pre-experimental negative affect showed that students from the PA condition had lower values in transfer compared to students from the control condition within the interval of $[-\infty, -182.5[$ for pre-experimental positive affect. As no student in the present sample had an initial positive affect within this interval, this result is not interpreted any further. Condition also did not make a difference in transfer for students with a pre-experimental positive affect within the interval $[-182.5, 3.0]$. There are 58 students (52.3%) in the sample who had values within this interval.

However, the PA condition was more effective than the control condition for students with a positive affect within the interval $]3.0, +\infty[$. As 53 students (47.7%) in the sample had values for pre-experimental positive affect within this interval, a positive effect of the PA condition on transfer can be expected for a considerable amount of the students. This pattern of results is the same for students having a pre-experimental negative affect below (see Figure 3.11A) or above average (see Figure 3.11C), but the slopes and the regions of significance for both conditions were significantly moderated by pre-experimental negative affect (see the interaction of pre-experimental positive affect by pre-experimental negative affect in Table 3.14).

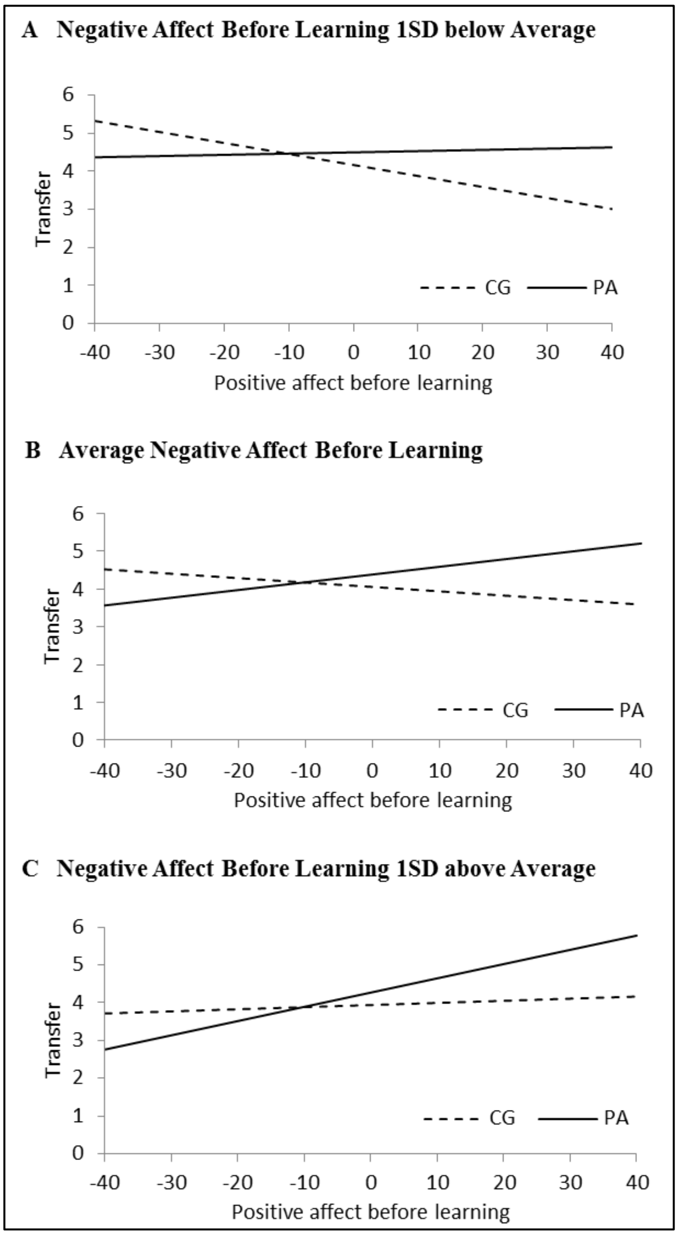

Figure 3.11. Regression of transfer on positive affect before learning for the positive affect condition (PA) and the control condition (CG) at three different levels of negative affect before learning in Experiment 2: (A) Negative affect before learning was 1 SD below average, (B) average negative affect before learning, and (C) negative affect before learning 1 SD above average. Positive and negative affect were centered before being entered as predictors.

To inspect this moderation in detail, the regions in which the regression of transfer on pre-experimental positive affect resulted in significant slopes were calculated. The regions of significance are thereby reported separately for each condition because slopes were significantly different for the PA and control condition.

For the control condition the slope of transfer on positive affect before learning was not significantly different from zero within the interval [-8.9, 17.3] for negative affect before learning. A total of 86 (77.5%) students had values for negative affect before learning within this interval. Thus, for most students, positive affect before learning was not related to transfer when learning under the control condition. The slope was significantly lower than $b = -.026$ for a negative affect before learning within]-∞, -8.9 [, and 16 students (14.4%) had values for negative affect within this interval. An illustration for this region of significance can been seen in Figure 3.11A, in which the regression line of transfer on positive affect for a negative affect of -10.8 is shown (this value is one standard deviation below the average). The slope was significantly higher than $b = .016$ for a negative affect before training within the interval]17.3, +∞[. In the current sample, 9 students (8.1%) had values for negative affect before learning within this interval. For the PA condition the slope of the regression of transfer on positive affect before training was not different from zero within the interval [-21.4, -1.2] for negative affect before learning. A total of 66 students (59.5%) had values for negative affect before learning within this interval. For those learners, positive affect before learning did not predict transfer. However, positive affect before learning predicted transfer inversely with a significant slope lower than $b = -.014$ for negative affect being in the interval [-∞, -21.4[. As no single person in the sample had values for negative affect within this interval this results is not of much interest for practical reasons. In contrast, 45 students (40.5%) had a negative affect before learning within the interval

]- .2, +∞[. For this interval the slope for the regression of transfer on positive affect before learning was significantly greater than zero and greater than b = .019. Learners in this interval therefore had benefits from learning under the PA condition. The regression line for a negative affect of zero is shown in Figure 3.11B, and the regression line for a negative affect of 10.8 (this is one standard deviation above average) can be seen in Figure 3.11C.

To sum up, it was not found that students learned more under the PA condition than under the control condition in general. However, students did comprehend more of the material in the PA condition if negative affect before the learning phase was high. From the remaining students, no student was in a region of initial negative affect in which the affiliation to the PA condition had caused negative effects on knowledge. Furthermore, it was found that students in the PA condition outperformed the students in the control condition in transfer if positive affect before the learning phase was high. Assuming an average negative affect before the learning phase, this was true for nearly 50% of the students. For the remaining students, the PA condition at least had no negative consequences concerning their performance in transfer.

Hypothesis 3 - Achievement Motivation. The third hypothesis of Experiment 2 implied that inducing positive affect via the design of the learning environment increases learning enhancing achievement motivation. Students who learned with the PA learning material should have had higher levels of mastery (Hypothesis 3a) as well as approach performance goal orientation (Hypothesis 3b) and lower levels of avoidance performance goal orientation (Hypothesis 3c) than participants who learned with the affectively neutral counterpart. In contrast to the analyses concerning comprehension and transfer, motivational variables were measured before and after the learning phase. Therefore a mixed MANOVA on achievement motivation sub scores (mastery, performance approach and performance avoidance goal orientation) as dependent variables with the time of measurement (pre- vs. post-measures) as within-subject factor and type of the learning material (CG vs. PA) as between-subject factor was computed. Using Pillai's Trace, there was a significant multivariate main effect of time, $V = .12$, $F(3,107) = 5.05$, $p = .003$, $\eta_p^2 = .12$. Separate univariate RM-ANOVAs were significant for all achievement motivation subscores (see Table 3.15).

Table 3.15

Univariate ANOVAs of the Main Effect of Time of Measurement on Achievement Goal Orientations before and after the Learning Phase in Experiment 2 (N = 111)

	F	p	η^2
Mastery goal orientation	12.19	.001	.10
Performance approach goal orientation	6.21	.014	.05
Performance avoidance goal orientation	4.67	.033	.04

Note. $df_{Model} = 1$, $df_{Residual} = 109$.

As stated earlier, means had decreased from pre to post measurement in the three types of goal orientation. However, there was no significant multivariate main effect of the type of the learning environment, $V = .02$, $F(3,107) = .60$, $p = .615$, $\eta_p^2 = .02$. Furthermore, analyses also revealed a non-significant interaction between the type of the learning material and the time of measurement, $V = .02$, $F(3,107) = .81$, $p = .489$, $\eta_p^2 = .022$. Therefore, Hypothesis 3 was not confirmed. The regression coefficients for all the models are reported in Table 3.16. As the only significant interaction was found for mastery goal orientation as the dependent variable and in order to maintain clarity, only this result will be described in more detail. In sum, the final model explained $R^2 = .66$ of variance in the mastery goal orientation after learning, $F(4,105) = 50.93$, $p < .001$, $f^2 = 1.94$. Variance was explained by the mastery goal orientation before learning but also by the positive affect before learning and by the interaction of positive

Table 3.16

Regression of Motivation after Learning (i.e., Mastery, Performance Approach, and Performance Avoidance Goal Orientation) on Condition, and Motivation, Positive, and Negative Affect Measured before Learning in Experiment 2 (N = 111)

	Mastery			Performance approach			Performance avoidance		
Predictors	*b*	*t*	*p*	*B*	*t*	*p*	*b*	*t*	*p*
Main effects model									
Intercept	50.35	31.30	< .001	45.09	22.32	< .001	38.51	20.63	< .001
Condition	-2.53	-1.16	.250	-.84	-.31	.759	1.26	.50	.620
Motivation[1]	.82	10.74	< .001	.81	10.11	< .001	.96	15.78	.000
Positive affect	.10	1.14	.258	.19	1.92	.058	-.08	-.86	.400
Negative affect	-.03	-.25	.807	< -.01	-.02	.985	-.01	-.06	.951
Interaction model									
Intercept	50.80	32.40	< .001	45.37	22.37	< .001	38.74	20.68	< .001
Condition	-2.72	-1.28	.203	-.95	-.35	.730	1.19	.47	.639
Motivation[1]	.84	11.16	< .001	.81	9.98	< .001	.96	15.72	< .001
Positive affect	.28	2.42	.017	.34	2.29	.024	.06	.44	.664
Negative affect	-.19	-1.30	.197	-.08	-.38	.705	-.08	-.40	.691
Condition x positive affect	-.34	-2.33	.022	-.27	-1.45	.151	-.24	-1.35	.180
Condition x negative affect	.31	1.59	.115	.15	.57	.567	.14	.59	.559
Final model									
Intercept	50.59	32.43	< .001	44.62	33.11	< .001	39.20	31.73	< .001
Condition	-2.64	-1.25	.213	---	---	---	---	---	---
Motivation[1]	.84	11.61	< .001	.85	11.70	< .001	.95	17.60	< .001
Positive affect	.30	2.62	.010	---	---	---	---	---	---
Condition x positive affect	-.37	-2.49	.014	---	---	---	---	---	---

Note. Condition was dummy-coded using the neutral affect condition as the reference group. Positive and negative affect were centered.
[1]The same sub-scale of motivation as the dependent variable but obtained before training and centered prior to the analysis.

affect before learning and the condition. The simple slopes were $b = .30$, $t = 2.62$, $p = .010$ for the NA condition and $b = -.06$, $t = -.60$, $p = .551$ for the PA condition, indicating that positive affect before learning predicted the mastery orientation after learning for students who learned with the neutral learning environment but not for students who learned with the PA environment (see Figure 3.12).

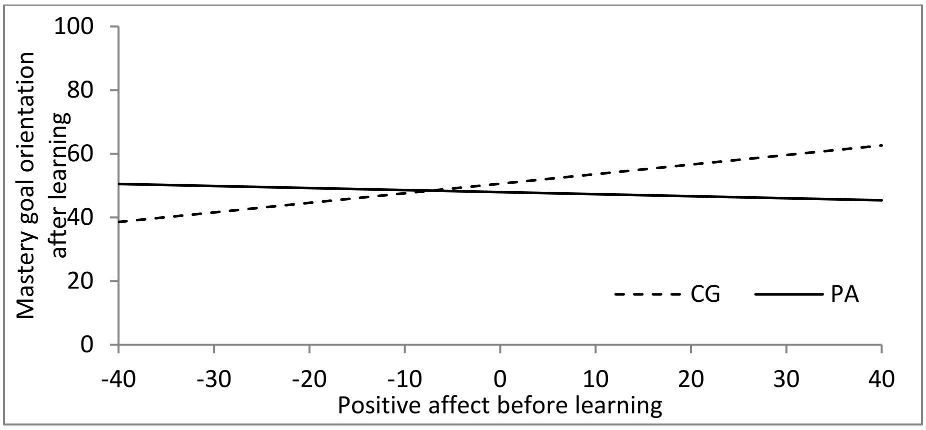

Figure 3.12. Regression of mastery goal orientation after learning on positive affect before learning for the control condition (CG) versus the positive affect (PA) condition in Experiment 2. Positive affect before learning was centered and mastery goal orientation before learning is held constantly at the average level.

Regions of significance were calculated to show the levels of positive activating affect in which there was a significant difference between the PA and the control condition in the mastery goal orientation after learning. There were no significant differences between conditions for mastery goal orientation when the positive affect before learning was within the interval [-43.0, 5.0], and this was true for 69 students (62.2%) of the sample. As no participant revealed a positive affect before learning that was lower than -43.0 the region below the interval is of no further interest. However, within the interval]5.0, +∞[for positive affect before learning, participants in the control condition reported significantly higher levels of mastery goal orientation than those in the PA condition. This was true for 42 students (37.8%) of the sample and is contrary to what was expected in the third hypothesis. Summing up the results concerning achievement goal orientations, there was no general main effect of PA condition vs. CG on the change of motivation during the learning. Levels of mastery goal orientation nevertheless decreased more for students in the PA condition than in the control condition given high levels of positive activating affect before learning.

3.2.6 Discussion of Experiment 2

The present experiment examined the influence of positive activating affect on learning outcome during multimedia learning. In general, the findings indicate a complex relation between affective states and learning outcome as well as, with some reservations, achievement motivation. Initially, it was assumed that participants who learned in an environment that induced positive activating affect by using bright and highly saturated colours and rounded shapes as design features (PA condition) would perform significantly better in knowledge and transfer than participants who learned in an affective neutral environment (control condition). It was found that participants in the PA condition outperformed those in the control condition depending on initial levels of positive and negative affect. Moreover, Experiment 2 presumed positive activating affect as being able to foster achievement goal orientations that are beneficial for learning. According to the data in Experiment 2, these assumptions could not be confirmed for performance approach and avoidance goal orientation because there were no differences between the two conditions. For mastery goal orientation results even indicate an inverse relationship, that is, learning under the PA condition was associated with a stronger decline in mastery goal orientation compared to the control condition. Results were generally only partly in line with the hypotheses, albeit they were not completely inexplicable. Quite contrary, there were several new insights gained due to striking, but unexpected moderating effects. Results for the hypotheses are further discussed in the next section. It is subsequently outlined why Experiment 2 provided substantial findings in the field and which implications can be derived from these findings.

3.2.6.1 Differences between Conditions in Experiment 2

Hypothesis 1 - Affect Induction. In contrast to Um et al. (2012), Experiment 2 revealed no significant increase in positive affect for the full sample. Positive affect while learning even slightly decreased in the full sample, though the effect was rather small. Because there were no differences in age or gender between the two conditions, the observed differences in learning outcomes nevertheless imply an effect of the independent variable at least for a subsample. Hence, it is possible that students who showed higher levels of affect before learning benefit from the treatment rather than students who did not in perceive strong affects. There are several possible explanations for an only partly successful treatment. Although several studies done in Plass's lab supported induced positive affect as facilitator of learning, results were not always consistent: Um et al. (2012) were able to induce positive affect using warm colours and anthropomorphic design elements that enhanced learning outcome; Plass et al. (2014) only found partly similar results, Park et al. (2015) even failed in inducing positive affect using the same methods. Mayer & Estrella (2014) also failed in replicating Um et al.'s (2012) initial findings completely, albeit trying for the first time outside of Plass's lab. Even though they were able to demonstrate learning gains using a similar emotional design, ratings of enjoyment of the learning session did not differ from a control condition.

Accordingly, it remains unanswered whether these gains were caused by affective states or other variables. The results found in Experiment 2 were therefore not completely contrary to existing studies, which also had difficulties in replicating the findings of Um et al. (2012). Unlike the majority of the above-mentioned studies, Experiment 2 did not use anthropomorphic design elements in the learning materials because it was assumed that these elements were not applicable for the learning topic. Besides, it was argued that baby-face like shapes of the figures in Plass's studies could also divert attention rather than figures that did not use these shapes. Consequently, using these elements might have caused learning gains because the information presented in the figures was more salient in the emotional design compared to the control condition. In contrast, the figures in Experiments 1 and 2 provided information related to the topic, but were not part of the learning test afterwards. More particularly, the figures were exclusively dedicated to enhance the efficiency of the affect induction. This ensured that performance was not increased due to better recognition or memorization. Moreover, the figures used in this experiment should not have disturbed performance on the premise that induced positive affect (rather than higher salience due to anthropomorphic design elements) was the mechanism that had caused learning gains in earlier studies. However, given the present results, it may have been the case that the treatment in Experiment 2 was not strong enough to elicit affective states in the full sample. As a result, it is advised to strengthen the affect induction in future research. Then again, it is also possible that the effectivity of the affect induction did not persist for the whole time of learning. Maybe the affect induction had more or less quickly worn out depending on inter-individual differences. Additional measurements of affective states are recommended to check for these difficulties. These thoughts have to be addressed in future research.

Furthermore, it may be that students who experienced strong levels of positive and negative affect before the learning phase had been more sensitive to a treatment that was intended to modify affective states. Consequently, the participant's ability to detect and express self-related affective states may intervene with self-reports of pre- and post-affect: Those who were sensitive to the treatment were sensitive for their own affect, that is, they were able to experience their affective state and report it in the questionnaire. Moreover, one's ability to successfully maintain positive affective states may also be of great importance as to successfully elicit affective states for longer periods of time as it was done in this work. Accordingly, the learners' competence in noticing and regulating own affective states might mediate the effectivity of the affect induction procedure. Additionally, it cannot be ruled out that the treatment used in this experiment might not directly have induced positive activating affect but rather related affective motivational constructs like interest. Durik and Harackiewicz (2007), for example, used colourful designed book pages to elicit situational interest in students. Therefore, the upcoming Experiment 3 will also control for interest as well as emotion regulation as a prerequisite for the induction of positive affect by means of colours or shapes.

Furthermore, although there is evidence that bright and saturated colours as well as round shapes are associated with positive activating affect (e.g., Boyatzis & Varghese, 1994; Kim et al., 2003), Elliot and Maier (2007) state that empirical findings are not consistent in this field of research. The authors particularly doubt that colours with longer wavelengths elicit physiological arousal. As a consequence, more studies have to be performed in which the colouring scheme is varied. Moreover, the induction method used in Experiment 2 is similar but not equivalent to the one that was used by Um et al.

(2012) and Plass et al. (2014). There had been several reasons for varying the induction procedure in Experiment 2 compared to the above-mentioned publications, such as reducing differences between the educational material in the PA and control condition concerning the attraction of attention or increasing the applicability of the treatment to learning content that does not allow the use of an anthropomorphic design. Yet, it remains an open question whether the two induction methods differ in eliciting affective states. Moreover, due to insignificant differences in pre- and post-affect it might also be assumed that the omission of anthropomorphic forms may create an affect induction that is too subtle for eliciting affective states that are perceived and expressed consciously by the learners. Although rather speculative, this might be an explanation for the lack of increased positive affect on the one hand and general differences in learning outcome on the other hand in Experiment 2. Therefore, it is indicated to compare the affect induction with and without anthropomorphic design elements experimentally in future research in order to ensure that the affect induction is strong enough to elicit positive activating affect for all participants. Henceforth, additional measures of affective states are required in order to control for the persistence of the affect induction.

Hypothesis 2 - Learning Performance. The results on learning outcome do not generally confirm the hypotheses because differences in learning between the PA and control conditions were not significant for knowledge and only marginally significant for transfer. This contradicts the results by Um et al. (2012) and Plass et al. (2014), who found that induced positive affect enhances learning outcome. Nevertheless, significant interaction effects were found when covariates were taken into consideration. For knowledge, the findings indicated that high levels of negative activating affect before learning predicted a decrease of learning outcome when no positive affect was induced. This is in line with previous work that showed that negative activating affective states can be detrimental for learning outcomes (e.g., Pekrun et al., 2009, 2010). However, participants' pre-experimental negative affect did not decrease knowledge in the PA condition in which positive activating affect was induced. Therefore, the present results imply that the induction of positive activating affect by the application of bright and saturated colours as well as round shapes during learning may protect participants with high initial negative affect from performance deficits. Moreover, participants who experienced high levels of pre-experimental positive affect performed significantly better in the transfer tasks in the PA condition compared to the control condition. In other words, participants that felt better before learning were significantly better in transferring knowledge into new contexts when they obtained the positive affect induction. This result supports earlier findings in which positive affect was associated with increased creativity and problem solving (e.g., Fredrickson, 2001; Isen et al., 1987). Similar to tasks that require creativity and problem solving, the transfer task used required the participants to detach their knowledge from the specific context of the learning material and to apply the knowledge to a new context that was not mentioned previously in the learning content. The supremacy of the PA over the control condition in transfer was further found for all levels of pre-experimental negative affect. Therefore, inducing positive activating affect increased learning outcome in transfer for students who experienced stronger initial positive affect. These results contradict findings of Um et al. (2012) who did not only induce positive affect while learning via the design of the learning material but also beforehand by using an imaginative and self-referencing induction method. Participants that received a positive affect induction and had to learn in the positive affect condition nevertheless did not outperform other participants. However, using the same materials, Park et al. (2015) found very similar results to those that were found in Experiment 2, that is, inducing positive affect through colour and shape can enhance transfer outcomes at least if positive affect before learning is high which is in line with similar findings by Park et al. (2015). Consequently, the present results contradict findings that have concluded a detrimental effect of positive activating affective states (e.g., Knörzer et al., 2016). Hence, in this experimental study, affective states before learning also predicted the success of an emotional design paradigm in order to enhance learning performance.

Hypothesis 3 - Achievement Motivation. Comparing both conditions regarding the magnitude of achievement motivation, the hypotheses of the present experiment have to be rejected. Although it was assumed that learning in a positive affect inducing learning environment fosters mastery and approach performance goal orientations, which are supposed as being beneficial for learning, there were no differences between the positive affect and control condition in any of the goal orientations. These findings differed from the results of Um et al. (2012) and other authors (e.g., Linnenbrink, 2007) who found an increase of intrinsic and extrinsic motivation when inducing positive affect. Aspinwall (1998) argued that positive affective states may reduce motivation to learn because the motivation of doing something (e.g., learning) that is likely to disrupt a current state of pleasantness should be rather low. Surprisingly, the results of Experiment 2 revealed a significant interaction, that is, students with high levels of positive affect before learning reported higher levels of mastery goals in the control condition than in the PA condition. Therefore, inducing positive activating affect predicted a decrease in mastery goals when participants had high positive activating affect before learning.

These results are different to previous studies (e.g., Ainley & Ainley, 2011; Um et al., 2012) and a meta-analysis by Huang (2011) reporting positive correlations between positive affect and mastery goals. Nevertheless, some works also found a negative relation (e.g., Brown, 2001). One possible explanation for these results addresses the measurement of achievement goals in Experiment 2. Because the induction of positive affect should enhance goal orientations that are beneficial for learning, achievement goals were measured on state rather than trait level by adapting an existing questionnaire that measures goal orientations. Although indicators of reliability were not inferior to the original questionnaire, it cannot be inferred that validity was achieved as well. In other terms, Experiment 2 did measure something that was assumed to be state goal orientation and these measures were quite reliable, but it is nevertheless not completely clear whether the reported scores really represent the intended constructs. However, even on the supposition that the adapted questionnaire measured state goal orientations as initially planned, the obtained non-significant results can be interpreted at least in two ways: First, there was no increase in levels of goal orientation because, contrary to trait goal orientations, positive affect and state goals are not positively linked. Second, the results of Experiment 2 indicate that a relatively small intervention (variation of the colours and shapes of the learning material) cannot significantly alter deeply entrenched constructs like goal orientations so easily. The first explanation seems rather unlikely because it is assumed that the changes that were made to measure state level did not vary the items drastically, that is, the adaptions should not have resulted in constructing completely unrelated orthogonal constructs compared to the original scale. Additionally, trait achievement goal orientations describe an individual's tendency to try to achieve certain goals in various achievement situations. State achievement goals on the other hand may contribute rather to the actual setting and can vary to some degree across different achievement situations, e.g., depending on experienced levels of control over the situation and the subjective value of reaching that specific goal (see Pekrun, 2006). Thus, trait and state levels should nevertheless be correlated substantially.

Moreover, there are findings that show that positive activating affect is associated with higher pursuit to accomplish one's goals in academic settings (e.g., Custers & Aarts, 2005). Albeit goal orientations can be altered experimentally (e.g., Latham & Locke, 1991; Winters & Latham, 1996), it is still more suitable to assume that goal orientations cannot be varied strongly by a slight intervention as realized in this experiment. Oddly enough, although there were positive correlations between positive affect and mastery goal that are in line with other correlational findings (see Huang, 2011), participants in the PA condition unexpectedly reported higher decreases in mastery goal orientation when initial positive affect was high. This more complex interaction is generally in line with assumptions of Linnenbrink and Pintrich (2002a) who postulated causal feedback loops between affective states and achievement goals. Nevertheless, the authors did not specify these assumptions detailed enough to explain the results of Experiment 2 sufficiently. Therefore, mechanisms underlying the influence of induced positive affect on achievement goals cannot be explained satisfactorily at the moment. It may be possible, albeit rather speculative, that the nature of the given task was not suitable to maintain high levels of mastery goal orientation because participants knew that their performance was about to be tested. Highly mastery oriented learners who typically learn in order to improve their knowledge and abilities might have been reminded to learn for high test scores by the design of the experiment, which caused their mastery goals to decrease. This effect might have been strengthened by high levels of positive affect before the learning phase. Assuming this to be true, the given setting might not be appropriate to investigate the influence of affective states on state goal orientations.

3.2.6.2 Conclusions of Experiment 2

To summarize, the present experiment's findings indicate a more complex relationship between eliciting positive affect and learning outcome as well as goal orientations in multimedia learning than what was initially expected. The induction of positive activating affect via the design of the learning environment did not necessarily facilitate learning outcome for all students. In fact, initial affective states have to be considered in more detail in future research. However, the results of Experiment 2 are generally in line with earlier findings that suggest that positive activating affect can be beneficial for learning, and therefore support the positive emotions as facilitator of learning hypotheses proposed by Um et al. (2012) rather than the idea of emotions being detrimental for learning (e.g., Knörzer et al., 2016). This experimental study also gave a first indication that bright colours and round shapes may protect learners from the negative impact of negative emotions before learning. Certainly, Shavelson and Towne (2002) recommend replicating and extending findings that have not yet proven to be consistent across studies, that is, additional research using other samples as well as materials is imperative. Therefore, Experiment 3 will further explore the complex interaction patterns found in Experiment 2. Experiment 3 will also extend previous findings by adopting a stronger affect induction intervention and taking additional control variables into consideration.

3.3 Experiment 3: Conceptual Replication of Experiment 2

3.3.1 Research Questions and Hypotheses of Experiment 3

As discussed in chapter 3.2.6, Experiment 2 indicated that an emotional design intervention, as the one proposed by Um et al. (2012), does not necessarily work for every learner. However, this is in line with other research that failed to fully replicate Um's et al.'s study. Moreover, the results did not support findings from Knörzer et al. (2016) in which positive activating affect, which had been induced by hearing music while remembering affectively loaded autobiographic events, was associated with learning impairments. Yet, Experiment 2's findings showed that the influence of positive activating affect on learning outcome depended on the levels of positive and negative affect prior to the learning phase which was also found by Park and colleagues (2015). Accordingly, moderating effects due to initial affective states may have caused the heterogeneous findings of earlier studies on the relation of positive affect and learning success, at least partially. Findings of Experiment 2 therefore extend the current state of research on enhancing learning outcome by inducing affective states largely. However, existing theories on the role of affective states on learning performance such as the CATLM (Moreno, 2005; Moreno & Mayer, 2007) do not specify when and at which point affective states influence the learning process. Results from Experiment 2 indicate, that there is a moderation effect of affective states prior to the learning situation on the effectiveness of an affect induction intervention to enhance learning performance. It is therefore assumed that the baseline levels of affective states have to be considered when investigating affect in the learning context.

Admittedly, when interpreting the results of Experiment 2 it was assumed that the affect induction procedures might not have elicited positive activating affect that was strong enough to work for every participant. It seemed therefore advisable to induce a stronger positive affect than before by adding anthropomorphic design elements to the learning environment. Although results on the effectivity of these elements are still inconsistent, there are several studies in which design elements like goggle eyes and baby-face images separately or in combination with bright and saturated colours induced positive activating affect (Plass et al., 2014; Um et al., 2012). Moreover, in order to understand the role of positive affect in the learning process it is rather irrelevant how the positive affect is induced; the underlying mechanisms should remain stable. In other words, the verification of the positive affect as facilitator of learning hypothesis should be independent from the sources of the affective changes. If the hypothesis is right, positive affect should influence learning outcomes positively no matter which induction method is used. Nevertheless, as discussed in chapter 3.2.3, there are some constraints concerning the addition of anthropomorphic design elements. Thus, the learning material has to be suitable and it has to be ensured that the elements induce positive affect without increasing the salience of the learning material. Otherwise, it would be questionable whether positive affect or better salience is the underlying mechanism.

However, because the affect induction should be stronger when anthropomorphic design elements are used, it is assumed that the participants' positive affective states will increase. Similar to Experiment 2, negative affect should be unaffected due to the orthogonality of positive and negative affective states. Therefore, Experiment 3 expects that:

H1a – Learning with a multimedia learning environment that uses bright and saturated colours and anthropomorphic figures as well as round shapes increases levels of positive activating affect during learning compared to a control condition.

H1b – Learning with a multimedia learning environment that uses bright and saturated colours and anthropomorphic figures as well as round shapes does not alter levels of negative activating affect during learning compared to a control condition.

Concerning the relationship between positive activating affect and learning performance, results from Um et al. (2012) found evidence that inducing positive affective states while learning can cause learning gains. Although the affect induction in Experiment 2 did not work as intended, it is nevertheless assumed that inducing positive affect can increase learning performance based on earlier findings and, perhaps even more importantly, a stronger and persisting affect induction is used. Furthermore, Experiment 3 uses an additional measure for memory retrieval because it has been shown that positive affect can enhance the recall of memory content (e.g., Heidig, Müller, & Reichelt, 2015), This measure will hereinafter be called recall. Accordingly, it is hypothesized that:

H2a – Participants who learn with a multimedia learning environment that uses bright and saturated colours and anthropomorphic figures as well as round shapes perform better in recall compared to a control condition.

H2b – Participants who learn with a multimedia learning environment that uses bright and saturated colours and anthropomorphic figures as well as round shapes perform better in knowledge compared to a control condition.

H2c – Participants who learn with a multimedia learning environment that uses bright and saturated colours and anthropomorphic figures as well as round shapes perform better in transfer compared to a control condition.

However, Experiment 2 also indicated that there are complex interaction effects when positive and negative affective states prior to the learning phase are considered. The moderation effects found in Experiment 2 were different for different measures of performance. Because Experiment 2 did not assess memory retrieval or recall as dependent variable, there was no data concerning a potential moderation effects of initial affective states on this specific learning outcome. However, positive rather than negative affect has been associated with better performance in remembering facts repeatedly (e.g., Heidig et al., 2015; Plass et al., 2014). Experiment 3 therefore assumes that positive affect will influence the recall of facts more than negative affect. Based on the results of Experiment 2, it is further assumed that initial levels of positive affect moderate the effectiveness of the positive affect intervention. Participants with higher levels of initial positive affect should benefit more from the affect induction concerning their performance in recall. Based on the findings from Experiment 2, a similar assumption can be derived for the moderation effect on transfer performance. Participants with high levels of positive affect are supposed to perform better in transfer when positive affect is induced. However, results for knowledge were quite different in Experiment 2. In fact, it was found that participants who reported higher levels of negative affect prior to the learning phase performed worse. These impairments I knowledge were not found, when positive affect was induced. Therefore, Experiment 3 assumes that the induction of positive affective states can protect against impairments in knowledge due to high levels of initial negative affect. Summing up, Experiment 3 hypothesizes the following moderation effects:

H3a – Participants who learn with a multimedia learning environment that uses warm colours and anthropomorphic figures as well as round shapes perform better in recall compared to a control condition when initial positive affect is high.

H3b – Participants who learn with a multimedia learning environment that uses warm colours and anthropomorphic figures as well as round shapes perform better in knowledge compared to a control condition when initial negative affect is high.

H3c – Participants who learn with a multimedia learning environment that uses warm colours and anthropomorphic figures as well as round shapes perform better in transfer compared to a control condition when initial positive affect is high.

Furthermore, Experiment 3 also considers the influence of different additional control variables and covariates like achievement motivation, interest, and emotion regulation competency that may mediate the relation between affective states and learning performance (as discussed in chapters 3.1.4 and 3.2.6). However, because the previous experiments did not show significant effects of the emotional design intervention on achievement motivation, Experiment 3 does not draw any specific hypotheses concerning this relationship. Experiment 3 is designed to verify hypotheses derived from the results of Experiment 2 following Schmidt's (2009) advice to conduct a conceptual replication. It is assumed that there is a complex pattern of main effects as well as moderation effects that differ for different measures of learning performance. Hence, Experiment 3 aims to provide unprecedented views on the complex interplay of positive affect and learning outcomes.

Nevertheless, Experiment 2 had not explicitly predicted the moderation effects positive and negative affective states prior to the learning phase on learning performance; they were found only in post-hoc analyses after covariates were taken into consideration. Therefore, a second aim of Experiment 3 is to test the robustness of these post-hoc findings using specific a priori hypotheses in order to verify the underlying mechanisms, that is, affective states before the learning phase can moderate the influence of positive affect on learning performance. According to Shavelson and Town

(2002) repeating studies is “the key to boosting certainty in results and refining theory” (p. 83). However, a recent study by Makel, Plucker, and Hegarty (2012) illustrated that the powerful methodological instrument of replications is crucially underrepresented in psychological research. Schmidt (2009) further defines several functions of replication studies. According to the author, the first four functions (controlling for statistical or measurement artifacts, avoiding sampling errors, generalising results to larger populations, and controlling for fraud) are techniques for a direct replication of a previous study. Direct replication studies often do not vary much of the experimental procedure, materials, contextual backgrounds, or the sample characteristics. Direct replications are used to confirm certain facts and expand knowledge on the generalisability of results to other samples. However, Schmidt (2009) also defined a fifth function which essentially expands the benefit of conducting direct replication studies: The verification of hypotheses in order to validate them and allowing to draw inferences to underlying theoretical explanations. These so-called conceptual replication studies are therefore of great value not only to confirm results but also to produce an understanding of underlying mechanisms and to verify theoretical assumptions. Moreover, conceptual replication studies are important to develop new and to extend existing theories. Experiment 3 is therefore designed to verify hypotheses derived from results of Experiment 2 in order to further elaborate on the positive affect as facilitator of learning framework (Um et al., 2012). Applying the definitions of Schmidt (2009), conducting a conceptual replication seems reasonable for obtaining this objective. Hence, in order to better understand the underlying mechanisms of the relationship between positive affect and learning outcome, Experiment 3 differs from Experiments 1 and 2 in terms of the affect induction procedures, learning materials, and performance tests.

3.3.2 Methods of Experiment 3

Experiment 3 used a similar design as Experiments 1 and 2 as well as additional control variables. In order to reduce redundancy only new instruments and design features are described in detail, the others will be referred to previous chapters, in which they were introduced. As in previous experiments, materials and instruments can be found in the appendix.

3.3.2.1 Sample and Design of Experiment 3

Experiment 3 assessed data of 151 participants. All of the attendees were undergraduate students from a German university. As in previous experiments, all participants were German native speakers. The online recruitment system introduced in Experiment 1 was used again for acquisition. Additionally, students were recruited by distributing flyers in student canteens, the university's main library, and several sports facilities in order to promote the experiment. Five participants had to be excluded due to high levels of prior knowledge. Additionally, one participant was excluded because of divergent levels of negative affective states at t1, that is, the person reported an average value that was three standard deviations higher than the median of the full sample. For the remaining 145 students the average age was 20.2 years (*SD* = 2.6; ranging from 18 to 32 years). Most of the students were female (100; 69%). Most frequently reported disciplines were media communication (102, 70.3%) and human computer interaction (39, 26.9%). One participant each reported to be studying German philology, informatics, mathematical physics, and sociology. Most of the students were in their first year of study with an average number of semesters of 1.6 (*SD* = 1.0). Due to computerized complete randomization, the final sample consisted of 65 participants in the control condition and 80 participants in the PA condition. Participants were once again tested in groups of up to 10 people, based on the number of registrations. As in Experiment 2, each participant was randomly assigned to either the positive affect (PA) condition or the affectively neutral control condition (CG). All students were asked to learn for 20 minutes on the topic of eukaryotic cells. Prior knowledge as well as trait levels of achievement goal orientations and emotion regulation were assessed as control variables in order to exclude confounding influences. Affective states were measured as dependent variables four times: Before the test for prior knowledge (t1), after the test for prior knowledge and before the learning phase (t2), after ten minutes of learning (t3), and after the learning phase (t4). Furthermore, motivational states were measured at t2 and t4. As in Experiments 1 and 2, learning performance was measured after the learning phase as dependent variable. The experiment's duration was about 60 minutes. As in the previous experiments, students received an hour of partial course credit for their participation.

3.3.2.2 Materials used in Experiment 3

Design of the Learning Environment. Experiment 3 used a similar set of multimedia learning environments as used in Experiment 2 (see Figure 3.13). Two sets of 12 nodes each on the topic of eukaryotic cells were programmed using HTML 5 and PHP script and presented using the Mozilla Firefox version 38.0 web browser (Mozilla Project, 2015). The learning content was about the structures and functions of different parts and organelles of eukaryotic cells including the biological membrane, the cell's core, mitochondria, ribosomes, the Golgi apparatus, and the endoplasmic reticulum. In sum, the learning content was about 1.600 words and accompanied by seven pictures of the cells' structures. As in previous experiments, participants could navigate using a navigation menu on the left-hand side of the screen or the browser's forward and

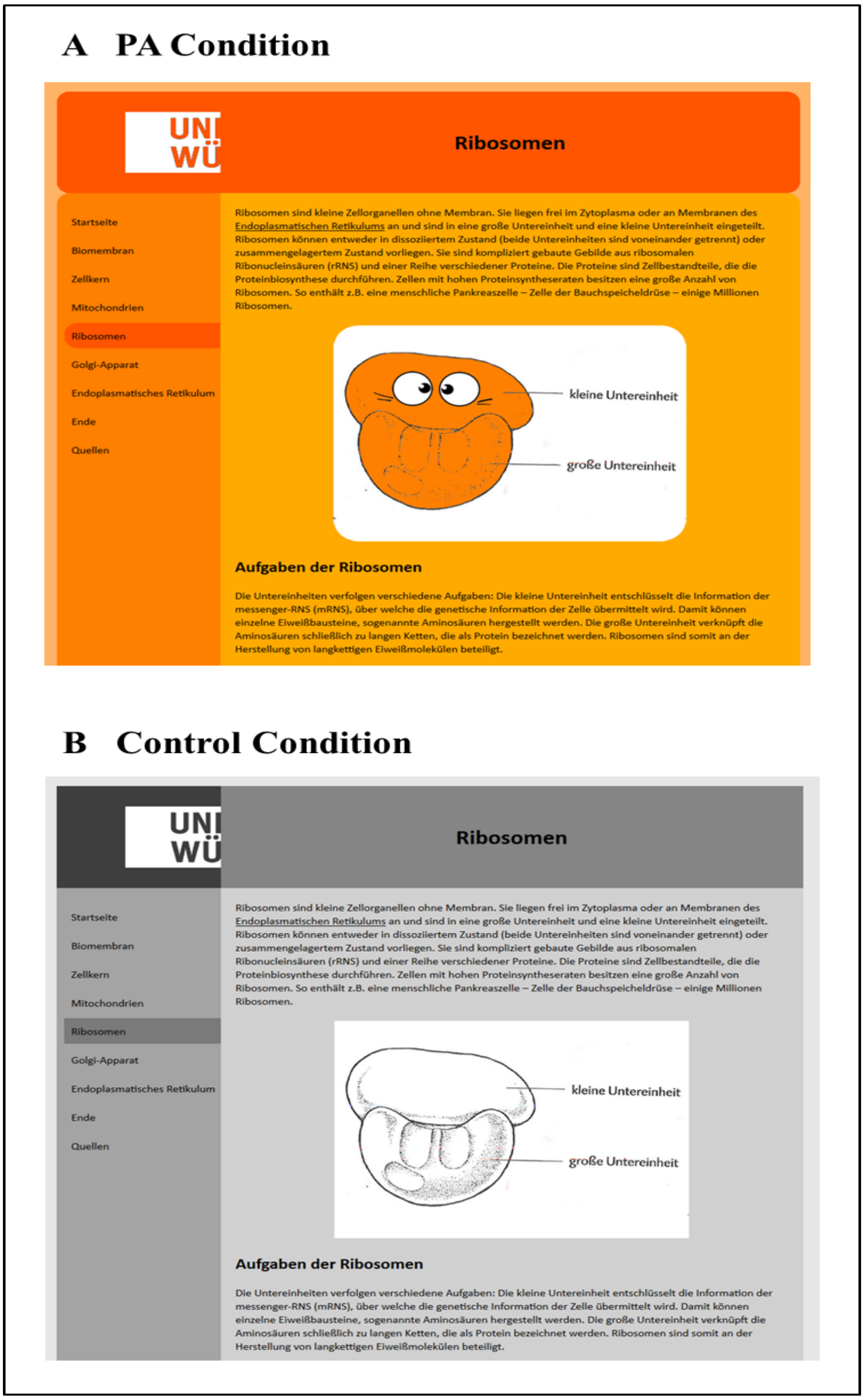

Figure 3.13. Screenshots of the two multimedia learning environments used in Experiment 3. (A) the multimedia learning environment designed to elicit positive affect by the use of bright colours, rounded shapes, and anthropomorphic elements, (B) affectively neutral counterpart using achromatic colours and sharp edges.

backward buttons. Moreover, pages were linked when technical terms were overlapping on different pages of the learning environment. Both environments were identical in text but differed in their emotional design. As in Experiment 2, the positive affect inducing learning environment used warm colours, specifically, bright and highly saturated colours of higher wavelengths (excluding red hues) as well as rounded shapes in the illustrating pictures. To ensure a stronger affect induction, this PA condition also used anthropomorphic elements by adding tiny faces, goggle eyes, and little accessories like hats or a monocle to the pictures. The affectively neutral control condition (CG) was similar to the control condition in Experiment 2 using achromatic colours as well as sharp edges. Moreover, none of the anthropomorphic design elements described above were added to the learning environment of the CG.

3.3.1.1 Measures used in Experiment 3

Prior Knowledge. Self-ratings of prior knowledge were assessed by asking the participants whether the topic of eukaryotic cells was (a) '… completely unknown', (b) '… partly known', or (c) '… completely known'. It was assumed that the contents of the learning material used in this experiment were more commonly familiar than those of the other studies because the topic is partly addressed in German schools when pupils choose to carry on participating in biology class[11]. In fact, participants were excluded without further consideration when they chose answer (c), which was the case for four students. Thirty-eight (25.2%) of the participants reported that the learning topic was completely unknown. 108 (71.5%) of the students reported to be partly familiar with the learning topic. As ratings based on one's own memory are typically susceptible to distortions and social desirability, more valid measurements of prior knowledge seemed adequate. Therefore, an additional test to check for prior knowledge was conducted. The test consisted of 24 multiple-choice items asking for several facts and relationships

[11] German pupils usually can choose between school subjects they want continue in the last two years of high school attendance.

between core concepts of the upcoming learning content, for example: ‘What would be the consequences if there was no Golgi apparatus in the eukaryotic cell? (a) ‘endocytosis would no longer be possible or would only be possible to a limited extent ‘, (b) ‘exocytosis would no longer be possible or would only be possible to a limited extent ‘, (c) ‘if damaged, cell walls and biological membranes would not be able to repair themselves ‘, or (d) ‘ATP could not be generated’. Items were rated on a 3-stage rating scheme ranging from zero to two points. Zero points were given for not choosing any of the correct answers. If at least one of the correct answers was chosen or if the participant selected wrong answers in addition to one or all correct answers, one point was given. The maximum of two points per question was given, if the participant correctly answered the question[12]. The mean score was calculated and used as an index for prior knowledge. It was further graphically controlled if there were any outliers in test scores of prior knowledge. However, boxplots did not reveal any significant outliers in the remaining sample. See Table 3.17 for descriptive statistics.

Activating Affect. Positive and negative affective states were measured once more using the German PANAS scales (Krohne et al., 1996). As in Experiment 2, the original Likert-scale was abolished and replaced by a more sensitive visual analogue scale ranging from zero (‘not at all’) to 100 (‘completely’). As in Experiments 1 and 2, reliabilities were quite satisfactory at all times of measurement (lowest value of Cronbach’s α = .87; see Table 3.17).

Trait Achievement Motivation. The students’ version of the SELLMO scales (Spinath et al., 2002) was used to measure trait achievement motivation analogously to

[12] A 3-stage rating scheme was used because of the lower guessing probability compared to for example rating schemes giving points for each correctly marked true and correctly unmarked false answer.

Experiment 1, that is, the work avoidance scale was not assessed. As in Experiment 2, the original Likert scale was changed into a visual analogue scale (0 = not at all' to 100 = 'completely') in order to ensure that even small differences were assessed accurately. As in previous experiments, the SELLMO proved to be reliable considering internal consistencies. In Experiment 3, the lowest value of Cronbach's α for achievement goal orientations was .84 (see Table 3.17).

State Achievement Motivation. Results in Experiments 1 and 2 revealed that achievement goal orientations did not change much although positive affective states were induced. Therefore Experiment 3 additionally assessed achievement motivation at state level using the FAM questionnaire (Fragebogen zur Erfassung aktueller Motivation [Questionnaire on Current Motivation], Rheinberg et al., 2001). The questionnaire is based on the 'classical' model of motivational psychology (Rheinberg, 2000, p. 70). According to this model, current motivation emerges because of the interaction of personal traits and situational factors. The FAM consists of four scales measuring fear of failure (which is called 'anxiety' by the authors), probability of success, interest and challenge. The first scale asks for the learner's fear of achieving badly or not achieving at all in academic situations as well as the apprehension to not being able to prepare sufficiently for a specific achievement performance assessment. The scale probability of success asks for the learner's estimation of how successful a certain achievement situation can be mastered or how easy a certain task is considered by the learner, taking into consideration the learner's skills and capabilities as well as situational circumstances. Interest measures the learner's estimation of the importance and the subjective value of the learning material and the given task itself. Challenge assesses the learner's current focus on achieving and performing well. According to the given instructions, all items are related to the learner's current attitude towards the given task or learning situation. In sum, the FAM consists of 18 items (4 items for probability of success and challenge; 5 items for fear of failure and interest). However, as recommended by Rheinberg et al. (2001) the item 'I like this kind of puzzles' in interest was changed for the learning situation in the present experiment to 'I like this kind of tasks'. Moreover, the item 'In this task I like the role of the scientist who discovers relationships' in interest was deleted because this item refers to the specific task learners had to perform in Rheinberg et al.'s (2001) validation studies. The FAM questionnaire in Experiment 3 therefore consisted of only 17 instead of the original 18 items. Analogues to the measurement of affective states and trait motivation the original 7-point Likert scale was replaced by a visual analogue scale ranging from 0 to 100. Rheinberg et al. (2001) provided additional information on the FAM's psychometric quality assuming that the questionnaire is both reliable and valid. Internal consistencies between .66 and .90 were reported depending on the given task. The present experiment found similar values with the lowest score for Cronbach's $\alpha = .70$.

Emotion Regulation. The present experiment used the SEK-27 (Selbsteinschätzung emotionaler Kompetenzen [Self-Report Measure for the Assessment of Emotion Regulation Skills]) by Berking and Znoj (2008) to measure the learners' emotion regulation skills. Although this questionnaire was originally derived from the field of clinical psychology, the authors demonstrated psychometric quality for practical uses by applying the questionnaire to non-clinical samples as well. Berking's (2010) model of effective emotion regulation emphasizes the constructive interplay of a variety of personal skills mediating one's handling of emotionally charged situations. According to the model, the following skills are required in order to regulate one's own emotions adequately: The conscious perception and recognition of affective states, the anticipation of possible sources of affective changes, the ability to generously accept and tolerate affective states, and the skill to support oneself emotionally in order to make an active emotion regulation possible. Based on this model, Berking and Znoj (2008) obtained 9 subscales of the SEK-27 using factor-analytical analyses. Each of these subscales targets one basic skills in the regulation of affective states and is measured with 3 items each: (1) Attention for affective states, (2) body awareness of affective states, (3) clarity in naming affective states, (4) understanding of affective states, (5) acceptance of affective states, (6) resilience in withstanding and tolerating affective states, (7) emotional self-support, (8) readiness for confronting oneself with affective states, and (9) the conscious regulation of affective states. Berking and Znoj (2008) argued that the SEK-27 can be used not only for diagnostic purposes but also for getting an idea of a person's emotion regulation competencies. The original 5-point Likert scale of the SEK-27 was replaced by the same visual analogue scale as for the other instruments. The SEK-27 can be analysed by interpreting the sub scores of each subscale or by calculating an average score over all items. According to the authors, internal consistencies were sufficient with values of Cronbach's α between .68 and .81 for sub scores and a value of .90 for the total score (Berking & Znoj, 2008). However, internal consistencies in Experiment 3 for the subscales were rather low in the present experiment with values of Cronbach's α between .51 and .66. Internal consistency for the total score was nevertheless quite good (Cronbach's α = .92). As the total score can be used as an indicator of a person's emotion regulation competencies, the average value over all items of the SEK-27 was used as a control variable.

Learning Outcomes. To test learning outcome Experiment 3 used a new set of performance tests as the learning environment changed compared to Experiments 1 and 2. The performance test in Experiment 3 consisted of three parts: (1) Remembering technical terms of the learning material (hereinafter called 'recall'), (2) knowledge, and (3) transfer analogously to Experiments 1 and 2. For recall, the participants were advised to write down all of the terms of the learning environment that they could remember. The sum of reported correct terms was used as an index for recall. Knowledge was measured using 24 multiple-choice items. The items were identically with those applied to the learners to test their prior knowledge. The average score of points per question was used as an index for knowledge analogues to the test for prior knowledge. In contrast to testing prior knowledge, two items had to be excluded from further analyses due to negative item selectivity. Therefore, the final score for knowledge was computed averaging the scores of the remaining 22 items. The transfer test consisted of four open questions as for example: 'According to the endosymbiotic theory, mitochondria originate from unicellular organisms that were assimilated from early eukaryotic cells. The eukaryotic cells were further able to perform cell respiration. Please name and explain the mechanism that made this possible.' As before, trained student assistants rated the answers. Indicators of reliability were sufficient with a Cronbach's α of .72 for knowledge as well as an average interrater reliability Goodman and Kruskal's gamma[13] of $\Gamma = .97$ for transfer which indicated a high correlation between the ratings. Participants could achieve between zero ('wrong/no answer') and 3 points ('completely correct answer') for each question. The average score of points per question was used as an index for transfer (ranging from 0 – 3).

[13] Gamma is used as an indicator of interrater reliability for ordinal data.

Table 3.17

Descriptive Statistics of the Variables in Experiment 3 for the Full Sample (N = 145)

	Number of items	Min[a]	Max[a]	*M*	*SD*	Internal consistencies[b]
Positive affect						
t1	10	6.80	87.40	50.17	15.01	.88
t2	10	2.40	87.00	41.72	18.19	.93
t3	10	1.70	84.80	40.45	20.51	.95
t4	10	1.30	77.80	37.73	19.56	.94
Negative affect						
t1	10	0.00	68.60	15.16	12.01	.87
t2	10	0.00	58.90	16.90	14.01	.89
t3	10	0.00	62.20	12.83	12.26	.89
t4	10	0.00	57.10	12.25	11.50	.88
Goal orientation						
Mastery	8	34.38	100.00	78.91	13.25	.87
Perf. appr.	8	7.14	96.29	54.75	17.72	.90
Perf. avoid.	7	0.00	86.35	31.57	17.83	.84
Interest						
t2	4	0.00	90.75	33.91	18.13	.80
t4	4	0.00	93.50	29.63	19.42	.86
Failure						
t2	4	0.00	75.40	24.95	18.77	.77
t4	4	0.00	73.00	22.81	18.54	.81
Success						
t2	4	0.00	100.00	51.48	20.35	.85
t4	4	0.00	99.50	55.49	20.53	.86
Challenge						
t2	4	4.50	96.00	51.80	18.51	.70
t4	4	0.00	100.00	49.57	21.18	.79
Emotion regulation						
Attention	3	33.11	94.89	64.77	13.18	.59
Regulation	3	31.90	95.05	64.95	13.14	.54
Confrontation	3	33.40	94.93	66.96	12.69	.51
Self-support	3	32.21	95.42	66.72	12.85	.51
Resilience	3	31.04	95.30	65.74	12.99	.56
Acceptance	3	32.84	94.79	66.59	12.76	.51
Understanding	3	31.50	95.33	65.30	13.39	.65
Body awareness	3	33.50	95.00	67.02	12.65	.60
Clarity	3	33.10	95.50	66.27	12.84	.66
Overall score	27	32.68	95.14	66.04	12.80	.92
Performance						
Recall[c]	---	2.00	29.00	13.86	6.32	---
Prior knowledge[d]	24	.42	1.25	.89	.16	.74[e]
Knowledge[d]	22	.64	1.50	1.16	.17	.72[e]
Transfer	4	.50	2.75	1.11	.65	.97[f]

Note. t1 = baseline; t2 = before the learning phase; t3 = after half of the learning time; t4 = after the learning phase; Perf. appr. = performance approach; Perf. av. = performance avoidance; [a] Using visual analogue scales from 0 – 100 except for performance indicators; [b] Cronbach's alpha; [c] Number of memorized correct technical terms; [d] 3-stage rating scheme from 0 to 2 points averaged for all items; [e] Interrater reliability Cohen's kappa; [f] Interrater reliability Goodman and Kruskal's gamma.

3.3.2.3 Procedure of Experiment 3

Data was collected in two waves with three months in between. After being welcomed by the experimenter, participants were informed about the duration and procedure of the upcoming experiment. Again, a cover story was used to mask the aim of the experiment. Specifically, the learners were told that the experiment was about navigating in a hypertext-based multimedia learning environment. In the course of the cover story, the participants were informed that their current attitudes would be assessed repeatedly, including halfway through the learning phase. This was announced to prevent from being surprised by the measurement of affective states during learning. After these explanations, the participants followed instructions on screen for the rest of the experiment in order to minimize the interaction with the experimenter. Accordingly, the experiment proceeded completely automatically as all of the questionnaires were given without any human interaction. First, participants were asked for their affective states for the first time. This measurement served as a baseline of the learners' affective states. Next, they were given several questionnaires to assess demographic variables, trait achievement motivation, as well as the participants' emotion regulation competencies. After the assessment of estimated as well as objective prior knowledge, affective states were measured the second time in order to detect changes due to the test of prior knowledge as well as motivational states for the first time. Participants were then led to either the positive affect inducing or neutral learning environment and were advised to read the content carefully and to memorize as much as possible. After ten minutes of learning, the third measurement of affective states was conducted. Affective and motivational states and were measured for the last time after another ten minutes of learning. Finally, learning performance in terms of recall, knowledge and transfer was measured. The total experiment was about an hour of time and, similar to the previous experiments, was administered using the SoSci Survey open source questionnaire tool by Leiner (2014). See Figure 3.14 for a visualisation of the procedure of Experiment 3.

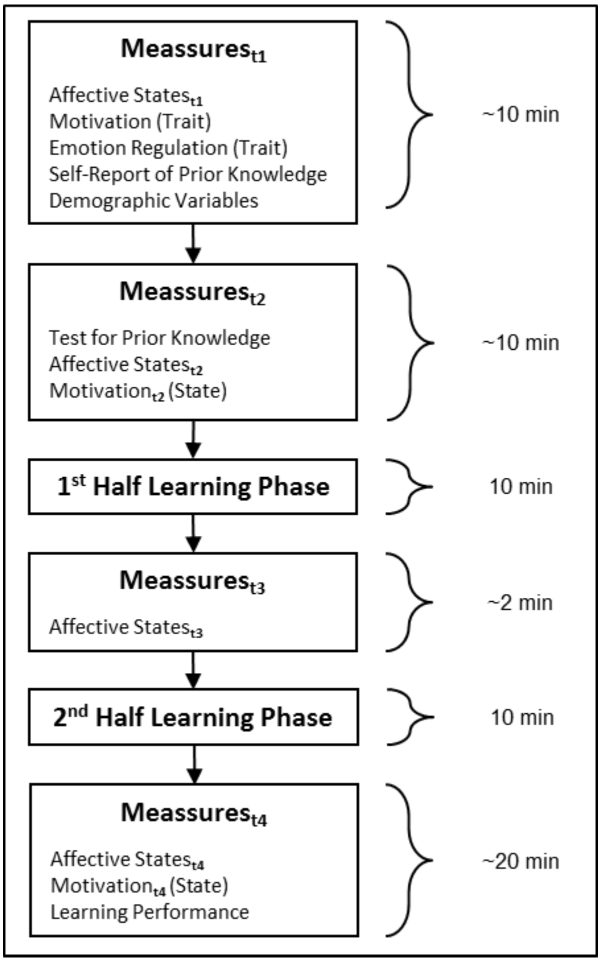

Figure 3.14. Procedure of Experiment 3.

3.3.3 Results of Experiment 3

As in Experiments 1 and 2, all analyses were conducted using IBM SPSS Statistics 22. If not stated otherwise, the significance level was set at 5% and all test assumptions were met. As before, group differences in control variables were checked first. Then, the manipulation of positive affect was verified in order to ensure a successful affect induction. Finally, stepwise regression models on learning performance with condition (step 1) as well as positive and negative activating affect prior to the learning phase (step 2) the interaction effects between condition and positive and negative affect (step 3) as predictors were conducted. As in previous experiments, externally studentized residuals were checked visually (scatterplots, histograms, and Q-Q plots) and it was controlled for collinearity. Test assumptions were checked as in the preceding experiments.

3.3.3.1 Preliminary Analyses of Experiment 3

This section consists of analyses that were done before the hypotheses were tested. As in Experiments 1 and 2, groups should not differ in any of the control variables as well as affective and motivational states before the learning phase. If there were any unexpected group differences, these variables would have to be considered as potential moderator variable and would have to be included into the hypotheses testing.

Descriptive Analyses. Descriptive statistics and reliability coefficients for the present experiment's measures are shown in Table 3.17. Coefficients for internal consistency were good to excellent for most of the measures except for the FAM's (Rheinberg et al., 2001) subscale 'challenge' and the subscales of the SEK-27 (Berking & Znoj, 2008). For challenge, internal consistencies were acceptable at t2 (before the learning phase) and good at t4 (after the learning phase). Alpha scores for the emotion regulation subscales were rather low with the highest score at .66. However, as the corrected item-total correlations were over .30 in all of the items (see Appendix F), it was assumed that the relatively small number of items per subscale had caused the low alpha scores. Moreover, test scores in the subscales were not relevant for the following analyses. In fact, the total score in the SEK-27 was used in order to control for group differences in emotion regulation because this score is an indicator for the general competency in regulating one's own affective experiences (see Berking & Znoj, 2008).

Cronbach's alpha for the total score was excellent. This indicates that the items of the SEK-27 measure emotion regulation as a general competency reliably. Regarding measures of learning performance, indicators of reliability were at least sufficient for knowledge and excellent for transfer. Hence, it unlikely that any of the measures were not trustworthy in terms of reliability. As it was found for Experiments 1 and 2, participants in Experiment 3 did not make use of the whole range of the visual analogue scales when reporting levels of negative affective states. This was not found for any other measure. Moreover and similar to Experiments 1 and 2, means for negative affect were lower than those for positive affective states at descriptive level. Something similar occurred for the FAM subscales 'interest' and 'failure'. Both scales showed relatively small mean scores although the complete range of the analogue scales was used. Measures of emotion regulation subscales as well as the emotion regulation total score were highly alike and did not show any anomalies. Changes over time were subtle for most of the repeatedly measures variables except for reported levels of positive affect. These scores decreased from t1 (baseline) to t4 about 13 scale points. However, these changes do not imply that positive affect decreased for all of the participants. Therefore, inferential statistical analyses were done in order to check for group differences in the change of positive affective states. Similar to Experiments 1 and 2, no participants achieved the minimum or maximum attainable test scores in any of the performance variables. Therefore, descriptive statistics for learning performance did not indicate any ground or ceiling effects. Moreover, means for prior knowledge were lower than means for knowledge. These changes indicate that participants performed better after the learning. Hence, it is likely that the learning environment was successful in providing relevant information to perform better in the test afterwards.

Correlational Analyses. Again, Pearson correlations between all variables were calculated (see Table 3.18). As in Experiments 1 and 2, reported levels of positive and negative affect were correlated positively across the four times of measurement. Similar to Experiment 1 and in contrast to Experiment 2, positive and negative affective states were not correlated with each other in Experiment 3. Again, mastery goal orientation was positively correlated with the baseline measure of positive activating affect, while high levels of performance approach goal orientation were associated with high levels of positive affect at the first and the measurement after the learning phase but before the learning test. Not surprisingly, negative affect was correlated positively with performance avoidance goal orientation at t1 and t2. These correlations are in line with previous findings in the literature (see Huang, 2011 for an overview). Moreover, positive affect was correlated positively with interest and challenge at all times of measurement and with success at t2 (before the learning phase) to t4 (after the learning phase). As expected, negative affective states were correlated positively with failure and negatively with success. This indicates that participants who felt more negatively also had higher levels of fear of making failures and were less likely to assume that they will master the learning situation successfully. A similar picture emerged when comparing affective states with emotion regulation competencies: While positive affect was correlated positively with each of the emotion regulation subscales as well as the overall score, negative affect and emotion regulation scales were correlated moderately negatively. Similar to correlations in Experiments 1 and 2, positive affective states were positively correlated with transfer and, to a lesser extent, with knowledge. Negative activating affect was correlated slightly negatively with learning outcomes but these correlations were not significant. However, trait achievement motivation as well as emotion regulation did not correlate with learning performance.

Table 3.18

Summary of Pearson Correlations between the Measures in Experiment 3 (N = 145)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Positive affect																
1. t1																
2. t2	.69**															
3. t3	.57**	.71**														
4. t4	.57**	.68**	.92**													
Negative affect																
5. t1	.03	-.02	.05	.09												
6. t2	.10	-.10	.03	.03	.65**											
7. t3	.12	.01	-.05	-.03	.57**	.73**										
8. t4	.06	-.04	-.07	-.08	.58**	.74**	.91**									
Goal orientations																
9. Mastery	.28**	.06	.10	.13	.00	.00	-.04	-.04								
10. Performance approach	.21*	.14	.19*	.23**	.12	.13	.11	.07	.28**							
11. Performance avoidance	.02	-.04	.09	.10	.17*	.16*	.09	.09	-.00	.63**						
Interest																
12. t2	.35**	.63**	.52**	.48**	.07	-.06	.05	-.01	.10	.12	.03					
13. t4	.33**	.57**	.60**	.58**	.09	.02	.02	-.03	.05	.04	-.02	.82**				
Failure																
14. t2	.07	-.10	.07	.05	.30**	.52**	.49**	.44**	-.10	.22**	.37**	-.03	.06			
15. t4	.05	-.03	.00	-.03	.26**	.42**	.53**	.56**	-.06	.14	.30**	.02	.06	.84**		
Success																
16. t2	.03	.27**	.18*	.19*	-.23**	-.37**	-.26**	-.23**	.07	-.01	-.07	.25**	.16*	-.43**	-.25**	
17. t4	.12	.24**	.42**	.46**	-.07	-.18*	-.25**	-.29**	.01	.08	-.10	.25**	.33**	-.27**	-.38**	.58**
Challenge																
18. t2	.50**	.48**	.44**	.44**	.05	.17*	.17*	.14	.20*	.43**	.35**	.48**	.39**	.33**	.31**	-.11
19. t4	.49**	.47**	.56**	.54**	.04	.05	.11	.08	.20*	.33**	.23**	.50**	.48**	.25**	.28**	.04
Emotion regulation																
20. Attention	.23**	.22**	.14	.15	-.20*	-.09	-.16*	-.15	.28**	.07	-.14	.04	.05	-.15	-.15	.09
21. Regulation	.22**	.22**	.14	.15	-.21**	-.10	-.16*	-.15	.28**	.05	-.14	.05	.07	-.16	-.15	.09
22. Confrontation	.21*	.23**	.15	.15	-.21*	-.11	-.19*	-.18*	.35**	.03	-.17*	.07	.10	-.19*	-.19*	.12
23. Self-support	.22**	.25**	.17*	.18*	-.23**	-.14	-.21*	-.20*	.34**	.04	-.16*	.07	.10	-.20*	-.19*	.15
24. Resilience	.22**	.24**	.15	.16*	-.22**	-.13	-.20*	-.18*	.32**	.03	-.16*	.05	.08	-.19*	-.18*	.12
25. Acceptance	.22**	.22**	.15	.15	-.22**	-.10	-.18*	-.17*	.33**	.04	-.16*	.04	.07	-.18*	-.17*	.11
26. Understanding	.22**	.22**	.14	.15	-.21*	-.10	-.16*	-.15	.28**	.05	-.15	.04	.06	-.16*	-.16	.09
27. Body awareness	.24**	.24**	.17*	.17*	-.21**	-.11	-.19*	-.18*	.35**	.06	-.15	.07	.10	-.19*	-.18*	.11
28. Clarity	.23**	.24**	.16*	.16*	-.22**	-.11	-.20*	-.18*	.34**	.05	-.15	.06	.09	-.19*	-.18*	.12
29. Overall score	.23**	.23**	.15	.16	-.22**	-.11	-.18*	-.17*	.32**	.05	-.16*	.05	.08	-.18*	-.17*	.11
Performance																
30. Recall	.09	.11	.21*	.22**	.03	.01	.01	-.01	.13	.12	.06	.25**	.23**	.05	-.02	.08
31. Knowledge	.06	.11	.19*	.20*	-.04	-.13	-.09	-.16	.01	.02	.05	.18*	.24**	-.04	-.11	.14
32. Transfer	.12	.23**	.32**	.31**	.05	-.10	-.14	-.16	.05	.09	.05	.27**	.28**	-.01	-.11	.13

Table 3.18 - Continued

Summary of Pearson Correlations between the Measures in Experiment 3 (N = 145)

	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
Positive affect															
1. t1															
2. t2															
3. t3															
4. t4															
Negative affect															
5. t1															
6. t2															
7. t3															
8. t4															
Goal orientations															
9. Mastery															
10. Performance approach															
11. Performance avoidance															
Interest															
12. t2															
13. t4															
Failure															
14. t2															
15. t4															
Success															
16. t2															
17. t4															
Challenge															
18. t2	-.03														
19. t4	.11	.78**													
Emotion regulation															
20. Attention	.10	.12	.10												
21. Regulation	.10	.12	.10	.99**											
22. Confrontation	.13	.13	.11	.95**	.96**										
23. Self-support	.15	.15	.14	.95**	.96**	.98**									
24. Resilience	.12	.14	.13	.97**	.98**	.98**	.99**								
25. Acceptance	.11	.13	.13	.97**	.98**	.98**	.98**	.99**							
26. Understanding	.10	.12	.10	.99**	.99**	.96**	.96**	.98**	.98**						
27. Body awareness	.12	.17*	.16	.95**	.97**	.99**	.99**	.98**	.99**	.96**					
28. Clarity	.12	.16	.14	.96**	.97**	.99**	.99**	.99**	.99**	.99**	.99**				
29. Overall score	.12	.14	.13	.98**	.99**	.99**	.99**	.99**	.99**	.99**	.99**	.99**			
Performance															
30. Recall	.19*	.14	.22**	-.08	-.07	-.04	-.04	-.06	-.05	-.07	-.03	-.04	-.05		
31. Knowledge	.30**	.14	.18*	-.08	-.06	-.01	.00	-.03	-.04	-.07	-.02	-.01	-.04	.43**	
32. Transfer	.37**	.18*	.25**	.05	.05	.07	.08	.06	.07	.05	.08	.08	.07	.48**	.58**

Note. t1 = baseline; t2 = before the learning phase; t3 = after half of the learning time; t4 = after the learning phase; * < .05, ** < .01

Interest before and after the learning phase as well as success after the learning phase otherwise were significantly positively correlated with learning performance. These correlations indicate that motivational states rather than traits or emotion regulation did influence learning outcomes in this experiment.

Differences Prior to the Learning Phase. First, group differences prior to the learning phase were checked for achievement goal orientations and emotion regulation conducting a one-way MANOVA with mastery, performance approach, and performance avoidance goal orientations as well as the average score of emotion regulation as dependent variables (see Table 3.19 for descriptive statistics). The Omnibus test showed no significant effect of condition, Pillai's Trace $V = .01$, $F(2,142) = .31$, $p = .871$, $\eta_p^2 = .01$. Furthermore, none of the univariate ANOVAs was significant. It was therefore assumed that the two groups did not differ in motivational traits as well as their emotion regulation competencies.

Table 3.19

Descriptive Statistics of Affective States and Control Variables in Experiment 3 (N = 145)

	Number of items	CG (n=60)		PA condition (n=85)	
		M	*SD*	*M*	*SD*
Positive affect					
t1	10	50.64	14.94	49.78	15.15
t2	10	42.11	18.89	41.40	17.70
Negative affect					
t1	10	16.29	14.64	14.24	9.53
t2	10	16.28	14.54	17.40	13.64
Control variables					
Mastery GO	8	78.75	13.89	79.05	12.80
Perf. av. GO	8	30.55	18.92	32.40	16.97
Perf. appr. GO	7	54.70	18.63	54.79	17.06
Emotion reg.	27	66.96	12.16	65.29	13.33

Note. t1 = baseline; t2 = before the learning phase; GO = goal orientation. Perf. av. = performance avoidance; Perf. appr. = performance approach; Emotion reg. = emotion regulation

Second, a one-way mixed MANOVA on positive and negative activating affect as dependent variables and condition as between-subjects factor as well as times of measurement as within subjects factor (baseline measure, t1 vs. measurement before the learning phase, t2) was conducted (descriptive data can be found in Table 3.19) in order to check for group differences in affective states at the start of the experiment as well as prior to the learning phase. Moreover, it was checked if affective states changed from t1 to t2 differently between the two groups. Using Pillai's Trace, Omnibus tests were only significant for the significant main effect of time of measurement, $V = .29$, $F(2,142) = 28.54, p < .001, \eta_p^2 = .29$. Univariate analyses were then conducted which showed a significant main effect of time of measurement on positive activating effect, $F(1,143) = 57.43, p < .001, \eta_p^2 = .29$. Descriptive statistics indicate that positive affect decreased in both conditions from t1 to t2. There was neither a significant main effect of condition, $V = .00$, $F(2,142) = .08, p = .927, \eta_p^2 = .00$, nor a significant interaction effect, $V = .02$, $F(2,142) = 1.61, p = .204, \eta_p^2 = .02$. Hence, positive and negative affective states did not change differently between the two conditions. Demographic variables were also checked to ensure a successful randomization. As in Experiments 1 and 2, there were no group differences in age, $t(143) = -1.64, p = .103$, or the distribution of gender, $\chi 2(1, N = 145) = .00, p = .950$.

Motivational Changes while Learning. As argued in section 3.2.6.1, it is at least assumable that the emotional design paradigm used in this experiment did not directly affect positive activating affective states but rather affective-motivational states like interest. It was therefore appropriate to check if the treatment did not erroneously affected interest instead of positive activating affect. That is why interest was measured before (t2) and after the learning phase (t4) in Experiment 3. In order to investigate the changes in interest a mixed ANOVA was conducted using pre- and post-experimental levels of interest as within-person factor and condition as between-person factor. Results revealed a significant main effect of time of measurement, $F(1,143) = 19.90$, $p < .001$, $\eta_p^2 = .12$. As can be seen in Table 3.20, interest decreased from t2 to t4 regardless of the condition. There was further no significant main effect of condition, $F(1,143) = .33$, $p = .565$, $\eta_p^2 = .00$, and no significant interaction effect, $F(1,143) = .00$, $p = .949$, $\eta_p^2 = .00$. Interest as an indicator of motivational states did not change differently between the two conditions. In other words, the treatment that was applied in Experiment 3 did not unintentionally influence interest. In order to control for confounding effects, pre- and post-measures of achievement motivation at state level were assessed.

Table 3.20

Descriptive Statistics of Motivational States in Experiment 3 (N = 145)

	Number of items	CG (n=60)		PA condition (n=85)	
		M	*SD*	*M*	*SD*
Interest					
t2	4	34.90	18.41	33.11	19.98
t4	4	30.55	21.83	28.89	19.40
Success					
t2	4	52.99	19.60	50.26	20.98
t4	4	53.93	21.51	56.76	19.74
Failure					
t2	4	25.79	19.43	24.26	18.30
t4	4	25.06	20.44	20.97	16.74
Challenge					
t2	4	52.26	19.12	51.42	18.11
t4	4	50.48	19.91	48.83	22.24

*Note.*t2 = before the learning phase; t4 = after the learning phase.

A mixed MANOVA was conducted with measures of success, failure, and challenge at t2 and t4 as repeated measures factor. The between-person factor was once again condition. The Omnibus test revealed a significant main effect of time of measurement, Pillai's Trace $V = .07$, $F(3,141) = 3.49$, $p < .05$, $\eta_p^2 = .07$. The effect was significant for success, $F(1,143) = 5.73$, $p < .05$, $\eta_p^2 = .04$, and failure, $F(1,143) = 5.28$, $p < .05$, $\eta_p^2 = .04$. For challenge, the main effect of time was only marginally significant, $F(1,143) = 3.87$, $p = .051$, $\eta_p^2 = .03$. Furthermore, there was neither a main effect of condition, Pillai's Trace $V = .00$, $F(3,141) = .34$, $p < .05$, $\eta_p^2 = .01$, nor a significant interaction effect, Pillai's Trace $V = .03$, $F(3,141) = 1.12$, $p = .313$, $\eta_p^2 = .03$. Looking at the descriptive data there were declines from t2 to t4 measures in failure and challenge (see Table 3.20). For failure, these decreases were stronger in the PA condition on a descriptive level indicating a possible interaction effect. However, given an adjusted alpha level of .016 this tendency was not significant, $F(1,143) = 2.15$, $p = .145$, $\eta_p^2 = .02$. Contrarily, scores for probability of success were higher after the learning phase compared to measures beforehand. The increase was stronger in the PA condition. However, this interaction also failed to reach significance, $F(1,143) = 3.19$, $p = .076$, $\eta_p^2 = .02$. Results therefore did not indicate changes in interest and other motivational states caused by the affect induction procedure. These variables therefore must not be taken into account as covariates.

3.3.3.2 Hypotheses Testing of Experiment 3

Hypothesis 1 – Affect Induction. In Hypothesis 1, it was expected that the emotional design intervention in the PA condition induces positive activating affective states (Hypothesis 1a) while negative affective states should be unaffected (Hypothesis 1b) compared to the CG. As in the previous experiments, participants were asked for their affective states before (t2) and after the learning phase (t4). Experiment 3 additionally measured affective states after half of the learning time had elapsed (t3). A mixed MANOVA with positive affect and negative affect at t2, t3, and t4 as within-person factor and condition as between-person factor was conducted in order to examine the changes of affective states while learning (descriptive statistics are shown in Table 3.21).

Using Paillai's Trace, the results of the Omnibus tests revealed a significant main effect of time, $V = .32$, $F(4,140) = 16.48$, $p < .001$, $\eta_p^2 = .32$. Univariate ANOVA's indicate declines in positive, $F(1.45,207.18)$[14] $= 7.33$, $p < .001$, $\eta_p^2 = .05$, as well as negative activating affect, $F(1.43,204.19) = 24.62$, $p < .001$, $\eta_p^2 = .15$. Post-hoc tests using the Bonferroni correction showed that the decline in positive affect was only true for the second ten minutes of learning ($p < .001$) but not for the first ten minutes of learning ($p = .743$). Pairwise comparisons for negative affect on the other hand indicated a significant reduction of negative affect within the first ten minutes of learning ($p < .001$), but not within the second ten minutes of learning ($p = .560$).

Table 3.21

Descriptive Statistics of Affective States at Measures 2 to 4 in Experiment 3 (N = 145)

	Number of items	CG (n=60)		PA condition (n=85)	
		M	*SD*	*M*	*SD*
Positive affect					
t2	10	42.11	18.89	41.40	17.70
t3	10	38.90	20.56	41.71	20.51
t4	10	36.49	20.11	38.74	19.17
Negative affect					
t2	10	16.28	14.54	17.40	13.64
t3	10	13.66	13.84	12.15	10.84
t4	10	13.24	11.91	11.45	11.18

*Note.*t2 = before the learning phase; t3 = after half of the learning time; t4 = after the learning phase

However, there was neither a significant main effect of condition, $V = .00$, $F(2,142) = .18$, $p = .836$, $\eta_p^2 = .00$, nor a significant interaction effect, $V = .02$, $F(4,140) = 1.07$, $p = .375$, $\eta_p^2 = .03$. Therefore, there were no significant differences in

[14] Degrees of freedom were adjusted due to violations of the assumption of sphericity. Because the estimates of sphericity were lower than .75 for positive as well negative activating affect, the Greenhouse-Geisser estimate was used (see Barcikowski & Robey, 1984).

the change of affective states while learning between the two groups. Positive affect was stable for participants in the PA condition, at least during the first ten minutes of learning on a descriptive level. In contrast, positive affect in the control condition continuously decreased while learning (see Figure 3.15A). Yet, this interaction was not statistically significant, $F(1.45,207.18) = 1.49$, $p = .228$, $\eta_p^2 = .01$. Negative activating affect continuously decreased from the first to the last time of measurement in both conditions (see Figure 3.15B). However, the decrease was stronger for participants in the PA condition on a descriptive level. Yet, this interaction effect did not reach statistical significance applying a corrected alpha level of .025, $F(1.43,204.19) = 2.63$, $p = .092$, $\eta_p^2 = .02$.

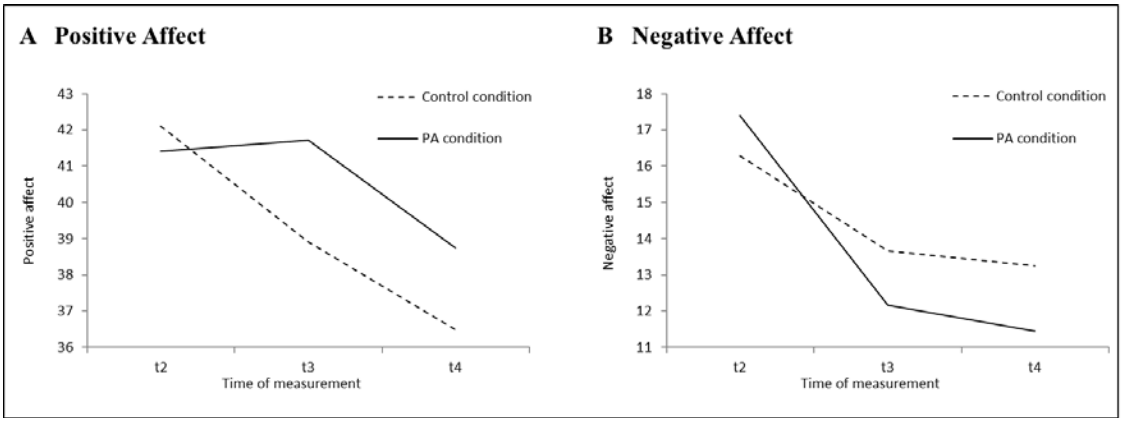

Figure 3.15 Scores of (A) positive and (B) negative affect using the PANAS scales for the treatment conditions before the learning phase (t2), after half of the learning time (t3), and after the learning phase (t4) in Experiment 3. PA = positive affect.

Given these results, learning with an affect inducing learning environment did not increase positive activating affect. However, on a descriptive level participants in the PA condition did not decrease in levels of positive affect from t2 to t3 as opposed to those in the control condition. Positive activating affect in the PA condition nevertheless decreased from t3 to t4 but did not descend to the levels reached by participants in the control conditions. As expected, negative activating affect did not change differently between the two groups, albeit negative affect decreased in both conditions. On a descriptive level, the decrease was stronger in the PA condition. Summing up, the manipulation check did not clearly support a successful induction of positive activating affect using an emotional design paradigm. Therefore, Hypothesis 1 had to be rejected.

Hypotheses 2 and 3 - Learning Performance. In Hypothesis 2, it was assumed that participants in the PA condition compared to those in the control condition perform better in recall retrieval (Hypothesis 2a), knowledge (Hypothesis 2b), and transfer (Hypothesis 2c) performance. Based on the results of Experiment 2, Hypothesis 3 additionally expected that the effects assumed in Hypothesis 2 could be moderated by the learners' levels of positive and negative affective states prior to the learning phase. When positive affect before the learning phase is high, participants in the PA condition should perform significantly better in recall (Hypothesis 3a) and transfer (Hypothesis 3b). On the other hand, when negative affect before learning is high, participants in the PA condition should perform better in knowledge (Hypothesis 3b).

As in Experiments 1 and 2, the hypotheses concerning the differences in learning outcomes between the control condition and the PA condition were tested using a stepwise multiple regression approach. First, condition was dummy-coded with the control condition being the reference condition and entered as a predictor into the regression model (condition only model to test for Hypotheses 2a-c). Second, a main effects model including positive and negative affective states prior to the learning phase was conducted. Next, interactions between condition and initial affective states were entered into the regression model (interaction model to test for Hypotheses 3a-c). Table 3.22 displays descriptive statistics for learning performance in terms of recall, knowledge, and transfer. It was further checked if interest in the learning topic might have predicted learning performance for all of the three dependent variables.

Table 3.22

Descriptive Statistics of Learning Performance in Experiment 3 (N = 145)

	Number of items	CG (n=60)		PA condition (n=85)	
		M	*SD*	*M*	*SD*
Learning performance					
Recall[a]	---	15.54	6.51	13.30	6.14
Knowledge	22	1.16	.17	1.17	.16
Transfer	4	1.08	.62	1.14	.68

[a] Operationalized as the number of memorized technical terms of the learning environment.

Hypotheses 2a and 3a - Affect and Recall. Table 3.23 shows regression analyses for recall. The condition only model showed that group affiliation did not significantly predict knowledge of the learning material, $R^2 = .01$, $F(1,143) = 1.38$, $p = .242$, $f^2 = .01$. Conditions therefore did not differ significantly in recall performance. Consequently, Hypothesis 2a had to be rejected. However, based on the results of Experiment 2 it was expected that learning with a positive affect inducing learning environment enhances recall performance when levels of initial positive affect were high. In other words, group differences in recall were not expected for all participants but only for those who were high in positive affect prior to the learning phase. Positive and negative affective states prior to the learning phase were therefore entered as predictors in the main effects model. Again, the model did not significantly predict recall performance, $R^2 = .02$, $F(3,141) = 1.09$, $p = .357$, $f^2 = .02$. The proportion of the explained variance in recall did not significantly increase by adding initial affective states into the regression model compared to the condition only model, $\Delta R^2 = .01$, $F(2,141) = .94$, $p = .394$. As can be seen in the interaction model in Table 3.23, first order interactions between condition and initial affective states did also not predict recall performance significantly, $R^2 = .04$, $F(5,139) = 1.19$, $p = .318$, $f^2 = .04$. The gain in the proportion of the variance explained by the model was also non-significant $\Delta R^2 = .02$, $F(2,139) = 1.33$, $p = .267$.

Table 3.23

Regression of Recall on Condition, and Positive and Negative Affect measured before Learning in Experiment 3 (N = 145)

	Recall		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	14.538	18.58	< .001
Condition	-1.238	-1.18	.242
Main effects model			
Intercept	14.561	18.59	< .001
Condition	-1.224	-1.16	.248
Positive affect	.039	1.36	.177
Negative affect	.012	.32	.748
Interaction model			
Intercept	14.510	18.55	< .001
Condition	-1.163	-1.10	.272
Positive affect	.018	.42	.673
Negative affect	-.043	-.79	.433
Condition x positive affect	.049	.84	.401
Condition x negative affect	.111	1.47	.144

Note. Condition was dummy-coded using the control condition as the reference group. Positive and negative affect were centered.

For the sake of completeness and to test for misspecification of the model, the interaction between positive and negative activating affect as well as second order interactions were checked. Moreover, initial levels of interest were added as a predictor into the regression model in order to control for confounding effects. However, none of these interactions did significantly predict recall performance. Given the present results, Hypothesis 3a was not met.

Hypotheses 2b and 3b - Affect and Knowledge. For knowledge, Hypothesis 3b assumed that participants in the control condition performed worse when initial negative affect was high. In contrast, participants in the PA condition were predicted not to show these declines in knowledge. To test for these interaction effects, a similar procedure as in Experiment 2 was used. Table 3.24 shows the results of the regression analyses. As before, the condition only model was not significant, $R^2 = .00$, $F(1,143) = .18$, $p = .670$, $f^2 = .00$, indicating that Hypothesis 3b was false. Adding initial levels of positive and negative affective states as covariates in the main effects model did not significantly increase the proportion of variance explained by the regression model, $\Delta R^2 = .03$, $F(2,141) = 1.98$, $p = .139$. As predicted, the main effects model did not predict knowledge significantly, $F(3,141) = 1.38$, $p = .251$, $f^2 = .03$. The proportion of variance in knowledge that is explained by the model was $R^2 = .03$. Contrary to Experiment 2, there was no significant gain in the predictive power of the model when first order interactions of condition and affective states prior to the learning phase were entered as predictors, $\Delta R^2 = .02$, $F(2,139) = 1.22$, $p = .298$. The interaction model explained less than 5% of the variance in knowledge which was not significant, $R^2 = .05$, $F(5,139) = 1.32$, $p = .259$, $f^2 = .05$. Again, interactions between positive and negative activating affect as well as second order interactions and the effects of initial levels of interest were checked. None of them significantly predicted knowledge in Experiment 3. Accordingly, Hypothesis 3c had to be rejected as well.

Table 3.24

Regression of Knowledge on Condition, and Positive and Negative Affect measured before Learning in Experiment 3 (N = 145)

	Knowledge		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	1.162	56.73	< .001
Condition	.012	043	.670
Main effects model			
Intercept	1.161	57.02	< .001
Condition	.014	.51	.610
Positive affect	.001	1.15	.251
Negative affect	-.001	-1.50	.135
Interaction model			
Intercept	1.161	57.09	< .001
Condition	.015	.04	.595
Positive affect	.000	-.10	.924
Negative affect	.000	-.31	.756
Condition x positive affect	.002	1.17	.243
Condition x negative affect	-.002	-.93	.357

Note. Condition was dummy-coded using the control condition as the reference group. Positive and negative affect were centered.

Hypotheses 2c and 3c - Affect and Transfer. Transfer performance was tested similarly to previous analyses. As before, the condition only model was not significant, $R^2 = .00$, $F(1,143) = .25$, $p = .619$, $f^2 = .05$. Therefore, Hypotheses 2c was rejected. Adding initial levels of positive and negative affective states as covariates significantly increased the predictive power of the regression model, $\Delta R^2 = .06$, $F(2,141) = 4.48$, $p = .013$, and explained $R^2 = .06$ of the variance in transfer, $F(3,141) = 3.07$, $p < .05$, $f^2 = .06$. Inspecting regression coefficients that are shown in Table 3.25 revealed that there was a significant main effect of initial levels of positive activating affect, that is, participants who felt more positive prior to the learning phase performed better in transfer, $b = .008$, $t = 2.73$, $p < .05$. However, adding first order interactions between condition and positive and negative affective states as predictors in the interaction model did increase the predictive power of the regression model any further, $\Delta R^2 = .07$, $F(2,139) = 1.24$, $p = .293$. The interaction model nevertheless significantly predicted transfer performance, $R^2 = .08$, $F(5,139) = 2.35$, $p < .05$, $f^2 = .09$.

Table 3.25

Regression of Transfer on Condition, and Positive and Negative Affect measured before Learning in Experiment 3 (N = 145)

	Transfer		
Predictors	*b*	*t*	*p*
Condition only model			
Intercept	1.085	13.36	< .001
Condition	.054	.50	.619
Main effects model			
Intercept	1.084	13.67	< .001
Condition	.064	.05	.548
Positive affect	.008	2.73	.007
Negative affect	-.004	-.08	.334
Interaction model			
Intercept	1.085	13.68	< .001
Condition	.069	.11	.520
Positive affect	.003	.09	.423
Negative affect	-.002	-.04	.748
Condition x positive affect	.009	.18	.138
Condition x negative affect	-.003	-.04	.711

Note. Condition was dummy-coded using the control condition as the reference group. Positive and negative affect were centered.

As can be seen in Table 3.25, none of the predictors in the interaction model was significant. Second order interactions as well as the interaction between positive and negative affect and interest prior to the learning phase were also checked and, as in the previous analyses, did not significantly predict performance. Summing up, the only significant predictor in transfer was positive activating affect in the main effect models. Hypothesis 3c therefore could only partially be confirmed, that is, participants who felt more positive before learning performed better, but there was no interaction effect between inducing affective positive affect and initial levels positive activating affect. However, there was no clear support for the hypotheses of Experiment 3, that is, initial positive and negative affective states did not moderate the influence of induced positive activating affect on learning performance. Moreover, there was no main effect of the condition. However, those participants who felt highly positive before learning performed better in transfer.

3.3.4 Discussion of Experiment 3

Experiment 3 was conceptually based on the results of Experiment 2. These results indicated a complex interplay of induced positive activating affect and affective states before a certain period of deep learning. As described earlier, these results were not predicted based on theory in Experiment 2. Experiment 3 therefore aimed to test these findings using a priori formulated hypotheses. Similar to Experiment 2, the participants learned either in a positive affect inducing learning environment (PA condition) or an affectively neutral counterpart (CG). Inducing positive activating affect therefore should have affected learning performance in two ways, each depending on the learners' initial affective states: (a) Enhancing transfer when positive affect before learning was high and (b) protecting against declines in knowledge when negative affect before learning was high. However, these assumptions could not be confirmed in Experiment 3. The experiment's hypotheses therefore have not been met. Yet, there was a main effect of positive activating affect on transfer performance that has been stable across Experiments 2 and 3. Moreover, the confounding of several control variables including interest and emotion regulation was taken into consideration and negated. The following section will discuss the experiment's results in more detail and will provide further implications.

3.3.4.1 Differences between Conditions in Experiment 3

Affect Induction, Motivation, and Emotion Regulation. Experiment 3 aimed to induce positive activating affect by applying emotional design elements that were adapted from other studies (Plass et al., 2014; Um et al., 2012). Affective states were measured four times: (t1) At the beginning of the experiment and before anything else was done with the participants; (t2) after acquiring demographic data and prior knowledge of the learning topic and prior to a learning period of 20 minutes; (t3) after half of the learning time had elapsed; and (t4) immediately after the end of the learning time. It was predicted that participants in the PA condition would report higher levels of positive affective states at t3 and t4 compared to the control condition due to the effects of the emotional design procedure. However, as in Experiment 2 there was no clear evidence for the success of the affect induction in Experiment 3. This was surprising given that anthropomorphic design elements were included that have shown to induce positive activating affect (see Plass et al., 2014). The affect induction procedure in Experiment 3 should have been even stronger than in Experiment 2, which had only used bright and highly saturated colours of longer wavelengths as well as rounded shapes as design elements.

However, on a descriptive level there were differences in affective states between the two conditions that met the assumptions: Participants in the PA condition reported higher levels of positive activating affect after ten minutes of learning than those in the control condition. Albeit decreasing during the second ten minutes of learning, the average level of positive affect after the learning phase was still higher in the PA condition. Positive affect in the CG otherwise decreased constantly while learning. Nevertheless, differences in affective states were neither statistically nor practically significant which is contrary to the initial findings of Um et al. (2012). Similar to the heterogeneous findings on the relationship of induced positive activating affect and learning outcomes, studies on emotional design paradigms also had difficulties in clearly eliciting positive activating affect using the techniques of Um et al. (2012). As described in chapter 3.2.3, there is still no consent on whether colours, rounded shapes, or anthropomorphic design elements are mainly responsible for inducing positive affective states. However, based on the results of Experiment 2 it was assumed that the affect induction procedure might not work for all learners. Experiment 3 further assessed a set of control variables that were associated with learning related positive activating affect, namely interest, state as well as trait measures of achievement motivation, and emotion regulation competencies. In order to indicate possible moderation effects, it was tested whether the two conditions differed in any of these variables. Yet, there were no differences between learners in the PA and the control condition in trait levels of emotion regulation as well as achievement goal orientations and motivational states. Although the importance of emotion regulation competencies in academic situations has been addressed previously (e.g., Pekrun, 2006), empirical findings that support these conceptual links are still relatively scarce.

Although Experiment 3 found positive correlations between high levels of emotion regulation and positive activating affect, participants reporting better emotion regulation competencies did not perform better in any of the learning outcomes. This is contrary to a few studies that found a positive relation between emotion regulation and learning outcomes (e.g., Graziano, Reavis, Keane, & Calkins, 2007). However, these studies often focus on emotion regulation in children (discussed in Eisenberg, Sadovsky, & Spinrad, 2005). Moreover, empirical studies most commonly concentrate on attention regulation as a part of emotion regulation (Blair, 2002) and its influence on social functioning rather than academic outcomes (e.g., Raver, 2002; Raver, Garner, & Smith-Donald, 2007; Sanson, Hemphill, & Smart, 2004). Furthermore, the present experiment could not find any evidence for emotion regulation interacting with the affect induction. Therefore, the present results did not indicate that emotion regulation competencies influence academic performance.

It was further speculated that the affect induction procedure might have enhanced interest rather than positive activating affect. Interest was positively correlated with measures of positive activating affect as well as better learning performance. Hence, the more the learners were interested in the learning topic the better they performed. This is in line with numerous studies that showed that situational as well as personal interest can be beneficial for learning (e.g., Ainley & Ainley, 2011; Hidi & Renninger, 2006; for a meta-analysis see Schiefele, Krapp, & Winteler, 1992). However, interest in the present experiment decreased while learning regardless of the learners' group assignment. If the treatment had erroneously fostered interest instead of positive affect, measures from before and after the learning phase would have changed differently between the two conditions. As this was not the case in Experiment 3, it is unlikely to assume that the treatment has affected interest. Accordingly, interest did not serve as a moderator in any of the dependent variables. Besides, the change in further indicators of achievement motivation at state level was checked. Reported levels of fear of failure and perceived challenge decreased while learning independently from the learners' group assignment. Again, if the treatment had caused these changes, they would have changed differently in the two conditions. Therefore, these declines did not occur due to the affect induction procedure. Measures of challenge on the other hand increased while learning. On a descriptive level, this increase was stronger in the PA condition compared to the control condition. However, this effect was still nonsignificant. Hence, it cannot be assumed that the affect induction influenced the learners' perception of competition.

Taken together, the results showed that the emotional design did not influence levels of achievement motivation. This is contrary to the results of Um et al. (2012) but similar to several other studies that failed in enhancing the learners' achievement motivation using a similar approach (e.g., Mayer & Estrella, 2014; Plass et al., 2014). Analogously to the results on learning performance, experimental findings on positive affective states and achievement motivation remain heterogeneous. Experiment 3 nevertheless found positive correlations between positive activating affect and probability of success as well as challenge. Learners who felt highly positive while learning more often believed in their own success and focused more strongly on performing better compared with others. Fear of failure was positively correlated with negative activating affect. Learner reporting high levels of negative affect also worried more about failing. Hence, correlational data is in line with plenty of research (for a meta-analysis see Huang, 2011).

Learning Performance. Experiment 3 hypothesized that participants who learned in a learning environment that induces positive affective states should perform better in transfer when initial positive affect was high and should additionally not suffer from declines in knowledge when initial negative affect is high compared to a control condition that used an affectively neutral learning environment. These hypotheses were derived from previous experiments that have shown that an emotional design paradigm that uses bright and highly saturated colours of longer wavelengths (excluding red hues) as well as rounded shapes and anthropomorphic design elements to induce positive activating affect can enhance learning performance (Plass et al., 2014; Um et al., 2012). Moreover, post-hoc results of Experiment 2 indicated that these effects depend on initial levels of positive and negative activating affect. According to this experiment's data, these assumptions could not be met, that is, there was no moderation effect of positive or negative affective states before learning. Furthermore, for recall and knowledge neither condition nor initial affective states did significantly predict performance. This is contrary not only to the results of Experiment 2 but also to other studies that found either main effects of an emotional design paradigm (e.g., Um et al., 2012), effects of initial affective states (e.g., Isen et al., 1987), or moderation effects between emotional design and initial affective states (e.g., Park et al., 2015). For transfer the present experiment found at least a significant main effect of initial positive affect that is in line with various previous findings (e.g., Isen et al., 1987; Um et al., 2012). This result therefore contradicts recent findings by Knörzer and colleagues (2016) who found that inducing positive activating affect while learning impaired learning performance.

According to Bless (2001), positive affective states are associated with more broaden-minded, creative and holistic information processing strategies, which may facilitate transfer performance. Yet, there was no significant interaction effect in transfer even though this effect was found in Experiment 2. Moreover, the predictive value of the regression model in transfer was rather low due to the relatively small proportion of explained variance in the dependent variable. However, results on emotional design paradigms so far are generally quite heterogeneous, that is, some studies found effects of affective states on learning outcome only when using a certain design element (see, for example, Plass et al., 2014). Likewise, similar design elements used in different studies affected measures of learning performance differently, that is, sometimes only transfer (e.g., Experiment 2 in this work) or comprehension performance (Study 1 in Plass et al., 2014) was increased, whereas other studies found a general learning enhancing effect (e.g., Mayer & Estrella, 2014; Schneider et al., 2016). As previously mentioned, Knörzer et al. (2016) even found that high levels of positive affect before the learning phase were negatively associated with learning performance when using a similar learning material as it was used in this experimental study. The results of Experiment 3 therefore do not solely contradict the initial findings from Um and colleagues (2012) and rank amongst the variety of different results on the same matter. Attempts to explain this heterogeneity are still insufficient. While studies on emotional design procedures commonly predicted that inducing positive affect can be beneficial for learning performance in deep learning situations, results of Experiment 2 indicated that the effect of the affect induction on learning performance depends on initial levels of affective states. Thus, it was suggested that these findings could serve as possible reasons for the heterogeneous findings so far. Therefore, Experiment 3 aimed to verify these results by performing a conceptual replication study. Because Experiment 3 nevertheless failed to confirm its hypotheses, it is evident that initial positive and negative affective states do not necessarily moderate the influence of induced positive affect on learning performance.

The study's experimental design and the affect induction procedure were quite similar to previous studies that were carried out from various researchers in different laboratories. In fact, most of the studies used very similar design elements in order to elicit positive affective states. Like most of the previous works, Experiment 3 further used a learning topic that was derived from the field of biology. It is therefore unlikely that the non-significant findings of the present experiment resulted because of different or inappropriate operationalisations. Accordingly, indicators of the instruments' reliability were sufficient for all measures in Experiment 3. Instruments to measure affective states were even identical to those used in many of the previous studies. Therefore, lacks of reliability as well as validity of the instruments as a reason for the non-significant findings do not seem very likely. Experiment 3 further controlled for several additional control variables including achievement goal orientations, motivational states, and emotion regulation. Results did not indicate any confounding effects caused by these variables. Finally, the sample size of nearly 150 participants is comparatively high for an experimental study on learning performance. Moreover, sample size was sufficient for analysing data using a moderated regression approach. Therefore, it is not reasonable to assume any restrictions due to low testing power. In sum, there is no obvious reason to doubt the presented results. Contrary to Experiment 2, it is therefore assumed that initial affective states did not work as moderators in Experiment 3. Given the recurring main effect of positive affect on transfer, it is nevertheless indicated that there is a relationship between positive activating affect and transfer. The results therefore support the positive affect as facilitator of learning hypothesis proposed by Um and colleagues (2012). Admittedly, the present experiment was not able to further specify these mechanisms.

3.3.4.2 Conclusions of Experiment 3

Results of Experiment 3could not confirm findings of Experiment 2 in which affective states prior to a complex learning task moderated the effectiveness of an emotional design approach in order to enhance learning performance. Experiment 3 therefore failed in bringing some kind of consistency into the contradictory data situation. Matching several other studies, it was nevertheless found that positive affect before the learning phase is associated with better transfer performance. Moreover, correlational findings were generally in line with the literature (see Pekrun & Stephens, 2011). Results of Experiment 3 therefore generally support the positive emotions as facilitator of learning hypothesis (Um et al., 2012). However, findings in Experiment 3 indicated that the treatment influenced neither positive activating affect nor the learner's interest in the learning topic. Keeping in mind the disparate findings of other studies regarding the effectiveness of the emotional design paradigm, it has to be questioned whether the applied affect induction procedure is effective and replicable in inducing positive activating affect in complex learning situations.

4 General Discussion

The main objective of the present work was to provide support for the emotions as facilitators of learning hypothesis proposed by Um et al (2012) and to elaborate underlying mechanisms that cause these learning gains. Therefore, three experiments were conducted, in which participants had to learn in a multimedia learning environment for a relatively short time: Experiment 1 examined the influence of positive and negative affective states that were induced experimentally before the learning phase. Experiment 2 investigated the effects of positive activating affect that was induced directly while learning on learning performance and achievement motivation. Experiment 3 aimed to conceptually replicate and extend the findings of Experiment 2. This chapter summarizes and discusses the findings of the three experiments in the broader sense. Section 4.1 contains the discussion on major findings of the three experiments including experimental as well as correlational data. Section 4.2 deals with methodological limitations and considerations regarding the research design, the samples used, and the selected measures. The last section further draws conclusions of the work and outlines possible directions of forthcoming projects in this area of research.

4.1 Discussion on Major Findings

Learning related affective states can crucially influence the learning process (Schutz & Lanehart, 2002). However, despite difficulties in comparing several studies due to different operationalisations of affective states, results on the role of learning related affects are quite heterogeneous (see section 2.2.3). One line of research argued that all types of learning related affect evoke task-irrelevant thinking that binds cognitive resources necessary to succeed in the learning task. Consequently, positive as well as negative affects should be avoided during achievement and learning situations (e.g., Ellis & Ashbrook, 1988; Seibert & Ellis, 1991). Several other researchers draw a more dynamic picture of the debate. Accordingly, different types of affective states can have different effects on learning outcomes. Deactivating affective states of both types of valence, like relaxation (positive valence) or boredom (negative valence), are typically seen as detrimental for learning (Pekrun & Stephens, 2011). In contrast, the impact of activating affective states such as feeling engaged and joyful (positive valence) or being confused or experiencing feelings of fear (negative valence) is the focus of numerous studies (D'Mello & Graesser, 2012; Dettmers et al., 2011; Frenzel, Thrash, Pekrun, & Götz, 2007).

As outlined in section 2.4, despite a variety of correlational findings, there is still a lack of experimental studies investigating affective states in controlled learning situations in order to gain information on the casual effects of affective states while learning. Moreover, the mechanisms underlying these effects as well as the influence of intervening variables are still relatively unknown. Accordingly, all three presented studies used an experimental approach to vary affective states in order to influence learning outcomes. Hence, it was expected that positive activating affect should be beneficial for learning while negative activating affect should impair learning outcomes. While the former assumption was based on the few studies that have indicated a positive causal relation between positive activating affects and learning outcomes (e.g., Um et al., 2012), the latter was derived rather from correlational findings (Pekrun et al., 2004) and some scarce experimental approaches (e.g., Schneider et al., 2016). The following section 4.1.1 outlines the empirical findings of the three experiments. The section therefore further divided into a section each for experimental and correlational data. Moreover, the section concerning experimental data further views learning performance and achievement motivation separately for reasons of clarity.

4.1.1 Experimental Manipulation

4.1.1.1 Learning Performance

Learning performance was measured in terms of knowledge, transfer (Experiment 1 to 3), and recall (Experiment 3 only). Knowledge was defined as the learner's ability to integrate facts from the learning environments in order to answer comprehension questions on the learning content. The ability of the learner to convey gained knowledge into new contexts was called transfer. Recall was defined as the ability of the learner to correctly remember and reproduce facts from the learning content.

In Experiment 1, it was predicted that the induction positive activating affect before learning should enhance knowledge and transfer while eliciting negative activating affect should have the opposite effect. To induce affective states, the participants watched either a positive (PA condition) or a negatively loaded film clip (NA condition). Participants who were watching an affectively neutral film clip should neither profit nor suffer from watching the clip in terms of learning performance (control condition). After the affect induction, the participants had to learn for 20 minutes in an affectively neutral multimedia learning environment. As presented in section 3.1.3, inducing positive and negative affective states was successful. Accordingly, there was at least some indication that learners in the NA condition performed worse in knowledge than participants in the control or PA condition. Hence, the induction of negative affective states might have caused learning impairments. However, there was no superiority of the PA condition in learning performance compared to both other conditions. Participants in the PA condition did not outperform those in the control condition in any of the performance measures. However, although positive activating affect was successfully elicited in the PA condition it was inconclusive whether the affect induction via film clips had evoked emotions that are self-relevant as well as related to the learning context (see Feldman Barrett, 2012; Gross, 1998) due to the null-effects concerning learning performance. However, Experiment 1 nevertheless allowed for an important insight in the role of affective states while learning by contradicting assumptions of the resource allocation theory proposed by Ellis and Ashbrook (1988). According to this framework, affective states that occur in the learning situation should generally impair learning performance (see also Knörzer et al., 2016). As there was no decline in learning outcomes for participants in the PA condition, the resource allocation hypothesis has not been supported in this research. Although the findings support other emotional design paradigms with regard to the broader issue (such as Mayer & Estrella, 2014; Schneider et al., 2016; Um et al., 2012), still more empirical and experimentally gained data is needed to falsify the resource allocation theory.

Following up on these ideas, Experiment 2 changed the affect induction procedure in order to induce self-relevant learning-related affective states directly while learning. Moreover, because findings of Experiment 1 reconfirm that negative activating affect can be detrimental for learning, Experiment 2 concentrated on the influence of positive activating affective states. Therefore, colours and shapes of the multimedia learning environment were altered. In fact, bright and highly saturated colours of higher wavelengths (except for red hue colours) as well as rounded shapes were used as design elements in the multimedia learning environment in order to induce positive activating affect in the PA condition. In contrast, the control condition used the same affectively neutral learning environment that was deployed in Experiment 1. Results concerning the affect induction did not generally support the effectiveness of the design elements, that is, positive activating affect did not increase while learning. Furthermore, the average learning performance in the PA condition was not significantly higher than in the control condition. However, post-hoc results of Experiment 2 revealed initial evidence for moderator effects that influence the impact of the induced affective states on learning performance. For knowledge, participants in the PA condition did not suffer from declines in performance when negative affect prior to the learning phase was high compared to those in the control condition. In other words, participants who experienced high levels of negative affect before the learning phase performed worse in knowledge when learning with an affectively neutral learning environment. Participants with high levels of initial negative activating affect who learned with a multimedia learning environment that was designed to elicit positive activating affect did not show decreases in knowledge. Hence, inducing positive activating affect may have protected against learning impairments in knowledge due to high levels of negative activating affect. For transfer, participants experiencing high levels of positive affect prior to the learning phase did generally perform better in the PA condition compared to the control condition.

These effects were also true for all levels of initial negative activating affect. Once again, these findings support the view of positive activating affect being beneficial rather than detrimental for learning outcomes, at least, if covariates are taken into consideration. Hence, the experiment confirmed the usefulness of an emotional design paradigm, at least for a part of the sample. Moreover, Experiment 2 affirmed the emotions as facilitator of learning hypothesis proposed by Um et al. (2012) and contradicted assumptions derived from the resource allocation theory. Mainly due to the experimental approach, initial positive and negative activating affect were found as possible preconditions for a positive relationship between learning outcomes and activity-related positive activating effect. Hence, the results of Experiment 2 may give additional insights concerning the mechanisms that underlie previous research that concentrated on correlational data.

Because the results of Experiment 2 were partially found a posteriori, Experiment 3 tried to conceptually replicate these findings using a very similar affect induction procedure and equivalent materials. Moreover, Experiment 3 sought to examine the influence of additional confounding variables and covariates such as motivational traits and states as well as emotion regulation competencies in order to further elaborate predecessors and consequences of inducing positive activating affective states while learning. In doing so, it was expected to further broaden the theoretical basis regarding the role of affect. Experiment 3 therefore measured affective states not only before and after the learning phase but also after half of the learning time had passed. As in Experiment 2, positive activating affect did not only not increase in the full sample, but even decreased while learning. Yet, there were additional information obtained by the intermediate measure of affective states: Positive activating affect decreased continuously in the control condition while participants in the PA condition reported stable levels of positive affect at the intermediate time of measurement. Afterwards, positive activating affect also decreased in the PA condition. At least on a descriptive level, participants in the PA condition nevertheless reported higher levels of positive activating affect after the learning phase compared to those in the control condition.

Cautiously interpreted, these findings might imply that the affect induction procedure has at least partially prevented decreases in positive activating affect. When compared to the few studies using a similar emotional design approach (Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012), these findings strengthen the picture that inducing positive activating by varying the colours and shapes of elements of a multimedia learning environment is quite difficult. Accordingly, none of the studies known to the author was successful in completely replicating Um et al.'s (2012) induction of positive activating affect and findings concerning the effects on learning outcomes. However, according to the findings of Experiment 2, positive activating affect was assumed to increase learning outcomes not for all learners but for those that were highly positively or negatively activated prior to the learning phase. Experiment 3 additionally measured recall performance as a learning outcome. Contrary to the results of Experiment 2, Experiment 3 could not replicate moderator effects of initial positive or negative activating affect in any of the performance measures.

Hence, the assumed dependency of the effectivity of the emotional design paradigm from initial affective states could not be confirmed. Nevertheless, Experiment 3 found a main effect of initial positive activating affect on transfer, which is in line with various studies (e.g., Isen et al., 1987; Plass et al., 2014; Um et al., 2012). However, Experiment 3 failed in conceptually replicating previous findings concerning the causal influence of learning-related affective states on learning performance.

4.1.1.2 Achievement Motivation

As comprehensively described in chapter 2 of this work, affective states, achievement motivation, and learning performance are closely related to each other. There are numerous studies referring to these relations. Moreover, motivational beliefs such as achievement goals as well as situational or personal interests are considered as antecedents of achievement emotions in Pekrun's (2006) control-value theory. Hence, due to the process-oriented conception of the model, several feedback loops and reciprocal linkages between affective states and achievement motivation are assumed. Learning performance on the other hand is seen as a consequence of the dynamic interplay between emotions and motivation as well as situational factors. In fact, studies differ in their view on the causal directions of these links. The cognitive affective theory on learning with multimedia (Moreno, 2005; Moreno & Mayer, 2007) argues that achievement motivation moderates and mediates the influence of affective states on learning performance. Finally, other researchers found evidence for achievement motivation being influences by affective states, thus, referring to motivation as consequence of emotional reactions rather than causes or moderating variables (e.g., Um et al., 2012).

Accordingly, Experiments 1 and 2 assessed achievement motivation in terms of goal orientations as a covariate in order to control for confounding effect of achievement motivation on the relation between affective states and learning performance. Hence, it was hypothesized that the induction of positive activating affect increases levels of achievement goal orientations that are beneficial for learning. Moreover, the experiments measured achievement goal orientations before and after the learning phase in order to check for differences in the change of achievement goal. As described in sections 3.1.3 and 3.2.5, goal orientations did not change much between the measurements. In addition, there were no interaction effect between the time of measurement and the group affiliation. Hence, inducing affective states did not affect reports of achievement goal orientations. This was contrary to other findings in which positive activating affect, which was elicited similarly, enhanced intrinsic achievement motivation (e.g., Um et al., 2012). Yet, it was further argued that motivational traits like goal orientations could not be varied by a relatively small intervention as the one performed in Experiments 1 and 2. Moreover, the discussion of Experiment 2 raised the question of whether an affect induction procedure using colours and shapes might have elicited affective-motivational states like interest rather than positive affect. Experiment 3 therefore assessed motivational traits in terms of goal orientations as well as motivational states and interest. However, none of these motivational covariates was influenced by the treatment. Moreover, there was no direct influence of motivational states on learning performance.

4.1.2 Correlational Data

Because the experimental manipulation in the three experiments did not clearly support the hypotheses of causal linkages between inducing affective states and learning outcomes, this section summarizes findings of the three experiments on correlative level. In Experiment 1, positive affect was neither positively nor negatively correlated with learning performance at all. This is contrary to other findings that have highlighted positive relationships between the two constructs (e.g., Isen, 2000; Fredrickson, 2001; Pekrun et al., 2002). According to the discussion of Experiment 1, inducing affective states with film clips might have elicited affect that was not completely related to the learning context and therefore, these affective states might not have been associated with learning performance that strongly. In contrast, Experiments 2 and 3 found significant associations between affective states and learning performance. In fact, positive activating affect was positively correlated with knowledge, transfer (Experiments 2 and 3), and recall (Experiment 3). Hence, the more the learners have felt positively engaged while learning, the better they performed. This is in line with a variety of studies (for an overview, see Pekrun & Stephens, 2012). Supporting several other findings, Experiment 2 further showed significant negative correlations between negative activating affect and learning performance. However, results of Experiment 1 did not show any significant correlations between achievement goal orientations and learning performance. This is contrary to numerous findings that have shown clear linkages between high levels of mastery as well as performance approach goal orientation and academic performance (for an overview, see Elliot & McGregor, 2001). Moreover, contrary to the findings of Experiment 1, there were significant positive correlations between goal orientations and learning performance in Experiments 2 and 3. As the instruments to measure affective states, goal orientations, and learning performance were almost identical in Experiments 1 and 2, it is rather unlikely that the characteristics of the questionnaires might have caused the null correlations in Experiment 1. Hence, it is suggested that the findings in Experiment 1 are rather a result of low testing power due to a relatively small sample. Summing up, with the exception of Experiment 1, results of this work are generally in line with correlational findings in previous studies. Because the majority of these studies investigated the role of affective states over longer periods of learning and achievement situations (e.g., school years or semesters), finding similar correlations during relatively short episodes of learning in this work is rather astonishing.

4.2 Methodological Considerations

In order to achieve its main objectives this work applied several methods such as different ways to elicit affective states, differently designed learning environments, and different questionnaires to measure dependent and control variables. As in any scientific work, there are methodological strengths and weaknesses in the present work. The following section discusses methods used in the three experiments with regard to the research design including considerations of the applied working definition of positive activating affect, characteristics and recruitment of the samples, and the measures that were used in the three experiments.

4.2.1 Research Design

Most of the findings on affective states while learning are based on correlative research designs. Yet, there are only a handful of experimental studies in this research field (e.g., Mayer & Estrella, 2014; Plass et al., 2014; Um et al., 2012). Hence, the experiments of the present work sought to elicit affective states in order to examine the effects on learning outcomes. Therefore, participants were randomly assigned to different conditions in order to ensure an experimental study design. In contrast to many of the existing studies that have assessed data over longer periods of academic learning (a school year, a semester), participants in the present experiments were instructed to learn only for a short amount of time within multimedia learning environments (20 minutes). Learning gains caused by induced positive activating affects indicated not only causal relations between affective states and learning outcomes but also that these improvements can be evoked in learning situations of rather short durations. Expressed in more methodological terms, the present experiments measured most of the dependent variables such as affective and motivational states before as well as after the learning phase (Experiments 1 and 2) or even in-between (Experiment 3). These repeated-measures designs have higher levels of testing power due to the additional explained variance within the conditions. Moreover, it is assumed that these approaches are superior in terms of internal validity because of the possibility to control for confounding variables. Taken together, the use of randomised control group designs in this work is a useful methodological approach for elaborating causal relations and broadening the standard of knowledge in this field of research. Moreover, one of this works objectives was to test whether these causal relations remain stable when applied to different learning contents. As described in section 3.3.1, the gold standard in order to verify hypotheses is to conduct a conceptual replication.

Yet, although the present work provided evidence for complex patterns of relationships between initial as well as induced positive activating affect and learning outcomes, these effects could not be confirmed by conducting a conceptual replication. The former results indicated that an experimental approach can be productive in identifying and validating affective states and its covariates facilitators of learning. However, the unsuccessful conceptual replication of the results of Experiment 2 clearly shows the high risks of this methodological approach. Although successful conceptual replications can crucially broaden the level of knowledge on a specific matter, the procedure remains a double-edged sword (see e.g., Hendrick, 1990). A conceptual replication can fail because the effects of the original study are not stable enough to be transferred to other experimental conditions. If this was the case, results of the conceptual replication can be of great worth in terms of generalizability of effect. However, failure can also occur due to misconceptions or flawed operationalisations in the replication study as well as due to, for example, statistical artifacts, sampling errors or even fraud in the original study. Hence, it is simply not possible to identify the reasons for the unsuccessful conceptual replication without a doubt. In other words, one gropes in the dark whether the original or the replication study caused the failure. To sum up, by enabling causal interpretations the experimental approach used in the present experiments provided valuable additional benefit in understanding the role of affective states in the learning context. Thanks to the experimental design, it was further possible to derive causal hypotheses from Experiment 2's post-hoc analyses. However, it has to be acknowledged that verifying these hypotheses by conducting a conceptual replication was a high-risk decision. Moreover, a more general dilemma of experimental research is the almost inevitable artificiality of laboratory investigations. Consequently, there might be restrictions concerning the external validity of the learning situation. Therefore, additional field studies are indicated.

4.2.2 Samples

According to Larzelere, Kuhn, and Johnson (2004), selection bias can be a serious threat to the internal validity of scientific studies. Moreover, inappropriate sampling can undermine even state-of-the-art empirical methods that allow for causal conclusions. In this respect, it is noted that the majority of the participants in the three experiments were female students at the beginning of their studies. Consequently, it was controlled for gender distributions and age in the conditions of the three experiments. As there were no significant differences in the male-female ratio or age in any of the experiments' conditions, it was assumed that possible effects due to gender or age did not influence the treatments differently in the conditions. Moreover, most of the tested students were studying media communication. Media communication is an interdisciplinary subject that includes communication sciences, media informatics, media psychology, and instructional psychology. The effects found in Experiments 1 to 3 can therefore not easily be generalized to other populations, including students of other subjects as well as non-student populations.

4.2.3 Measures

The present experiments used a variety of different self-report questionnaires in order to assess dependent variables as well as control variables and covariates. However, there are some considerations on the use of self-report questionnaires in the present work: First, the assessment of positive and negative activating affect might have been compromised in several ways due to single-source biases. In his component process model, Scherer (1984) defined affective states as different patterns of appraisals regarding affective, cognitive, motivational, peripheral physiological and expressive components of emotional experiences. Self-report questionnaires such as the PANAS scales do not address all of these components and therefore may not be sufficient for measuring affective experiences exhaustively. Moreover, although the intermediate measures of affective states in Experiment 3 led to more detailed information on the affective changes while learning, the dynamics of affective states proposed by D'Mello and Graesser (2012) still cannot be observed using questionnaires. Furthermore, there is some indication that positive and negative affect in the sense of Tellegen and colleagues (1999) are not completely orthogonally (Feldman Barrett & Russell, 1998). Hence, it is at least questionable whether the fundamental dimensions describing affective states – valence and activation – are diagonally structured in-between positive and negative affect/activation in the circumplex. Therefore, future research should consider these limitations by using multiple methods to assess affective states, such as physiological data as well as video recordings of the learning situation. Second, as a more general restriction, the use of self-report questionnaires to assess process-oriented data such as affective or motivational changes can for example be influenced by social desirability or recall distortions when the questionnaire is applied retrospectively. Finally, although items that measured learning performance were checked for item statistics such as item difficulty and discriminatory power, some of the indicators for reliability were only acceptable in the present experiments. Hence, further studies are needed in order to validate measures of learning performance in order to ensure reliable findings.

4.3 Conclusion and Outlook

This dissertation's main objective was to gain deeper insight in the role of affective states in the learning context. Hence, it was sought to extend existing correlational findings by applying an experimental research approach. In doing so, it was aimed to draw causal conclusion on the effects of affective states on learning outcomes. Consequently, three experimental studies have been conducted: Experiment 1 aimed to specify the effects of inducing positive and negative activating affects before the learning situation, Experiment 2 focused on finding evidence for learning gains due to an emotional design paradigm inducing positive activating affect directly while learning, and Experiment 3 was conducted in order to conceptually replicate the previous findings. Although experimental data in the three experiments did not clearly show positive causal effects of positive activating affect on learning outcomes in terms of performance and achievement motivation, this work nevertheless provided additional evidence for positive emotions' ability to facilitate performance in multimedia learning. These findings fit into the current state of empirical knowledge in this field, that is, causal relationships between affective states and learning outcomes are assumed but these findings are hard to replicate, even when using the same materials. Moreover, the results of Experiment 2 indicate that the induction of positive activating affect using an emotional design paradigm did not work for everybody but only for those who reported high levels of initial positive or negative affect. Consequently, causal effects of the induced affective states may also apply only for a subsample of the learners. Hence, this work revealed previously not reported complex patterns of interactions between the induction of affective states and pre-experimental positive and negative affect in a short-time learning situation. However, the question of repeatability of these results cannot be ultimately answered, as the conceptual replication of Experiment 2 was not successful. Hence, the assumed complex relationships between affective states before and during learning and learning outcomes have yet to be clarified. Although the treatment seemingly worked for at least some of the participants, research in this emerging field has not yet clearly identified, which other characteristics determine the validity of the emotional design. From an instructional point of view, the understanding of the mechanisms that elicit positive affect during learning is useful for improving outcomes and should therefore be further investigated in future research.

Nevertheless, the present results on learning outcomes form a consistent picture: Inducing positive affect while learning predicted better knowledge and transfer for participants with high levels of initial positive or negative affect. If these patterns remain stable in future research, such treatments will require taking initial affective states of the learner into consideration. Moreover, even if not specified explicitly in the hypotheses, correlative results were very similar to those of other studies. This is rather astonishing on the one hand because of the short duration of the learning situations. On the other hand, the results further support the idea of positive activating affect being beneficial in the learning context.

Future research will have to show whether emotional design paradigms can confirm their assumed usefulness. Subsequent studies thereby are obliged to replicate the few experimental findings and, furthermore, to elaborate underlying mechanisms in order to develop more sophisticated theoretical frameworks. Following the results of the present experimental studies, theories will have to consider the effect of potential moderation effects due to initial levels of positive and negative affective states more profoundly. The present work gives initial evidence for complex interaction patterns that depend on the type of activating affect (positive vs. negative) as well as the type of learning performance (knowledge vs. transfer). Moreover, future research is also obliged to consider methodological issues such as the multi methodical measurement of affective and motivational states as well as transferring the learning content into contexts other than STEM subjects (i.e., mathematics, information technology, natural sciences, and technical disciplines). However, in the end, treatments for fostering learning outcomes have to be applicable in real classrooms. Consequently, medium to long-term objectives lie in the implementation of successful emotional design approaches in real learning situations instead of achievement situations that are created artificially in laboratory settings.

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List of Tables

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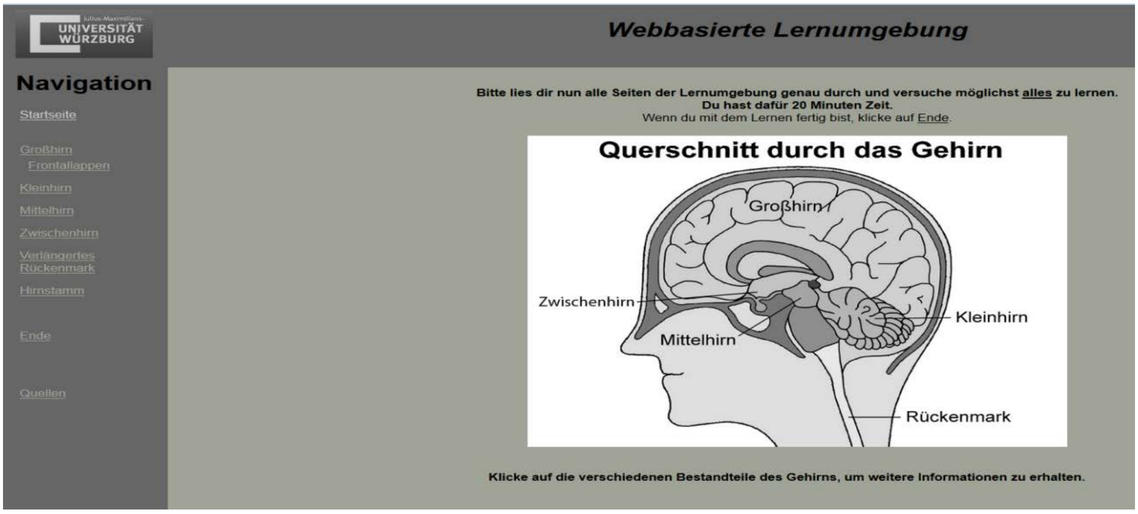
Appendix A: Learning Environments used in Experiments 1 to 3

Appendix A1: Learning Environment used in Experiment 1

Page 1:



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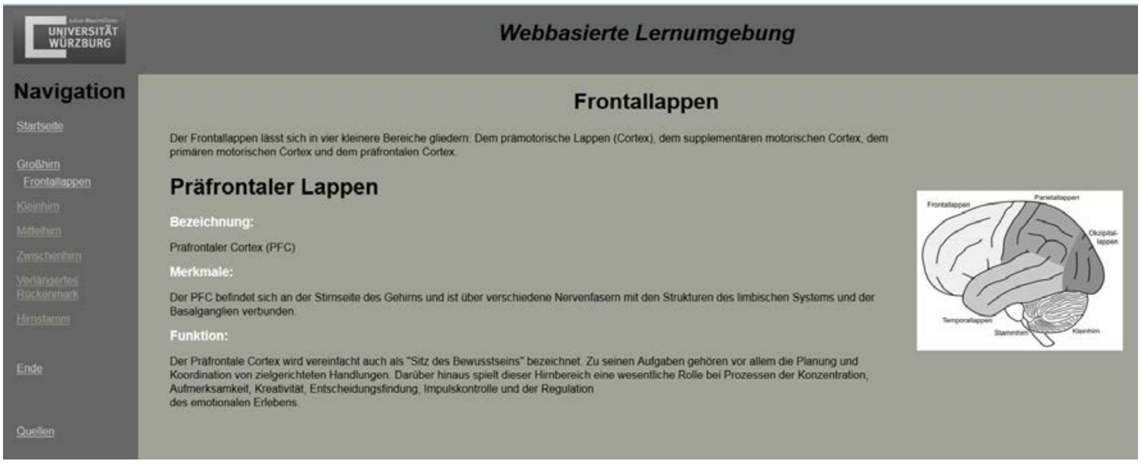

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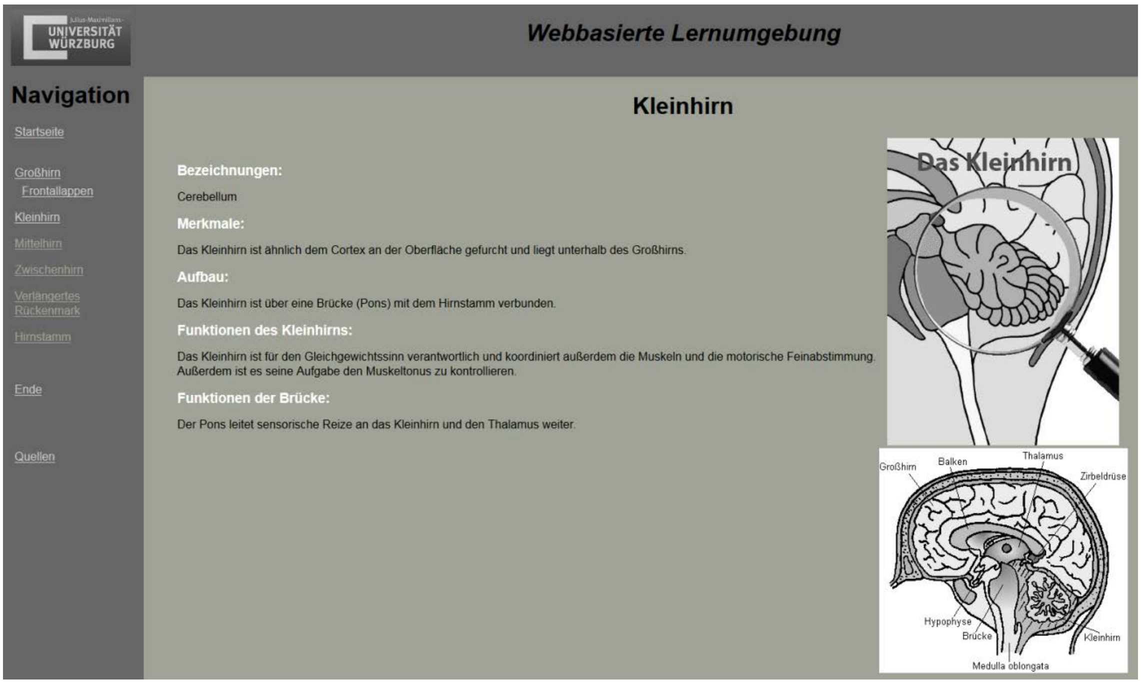

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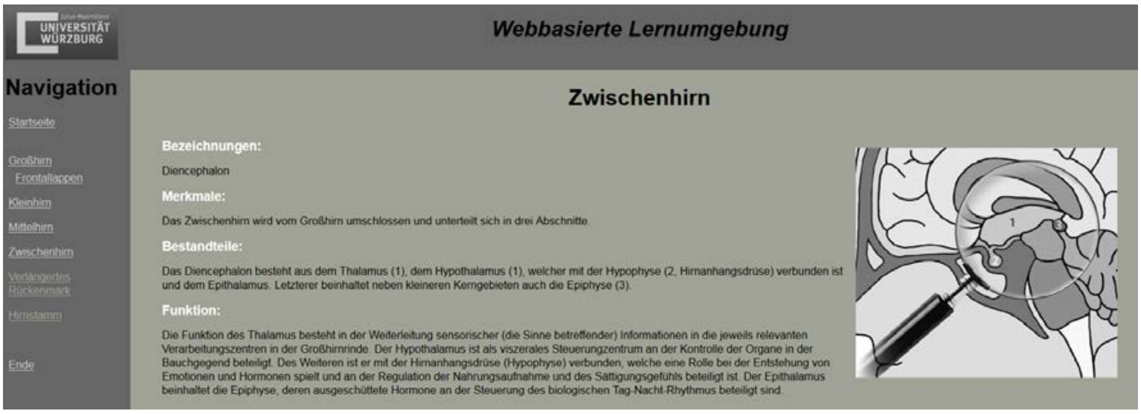

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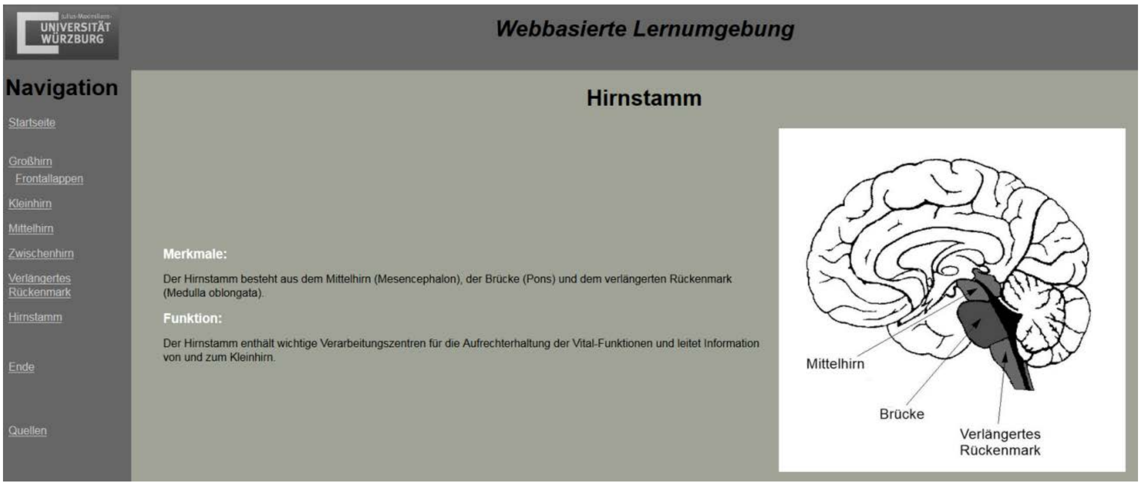

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Appendix A2: Learning Environment used in Experiment 2

a) Control Condition:

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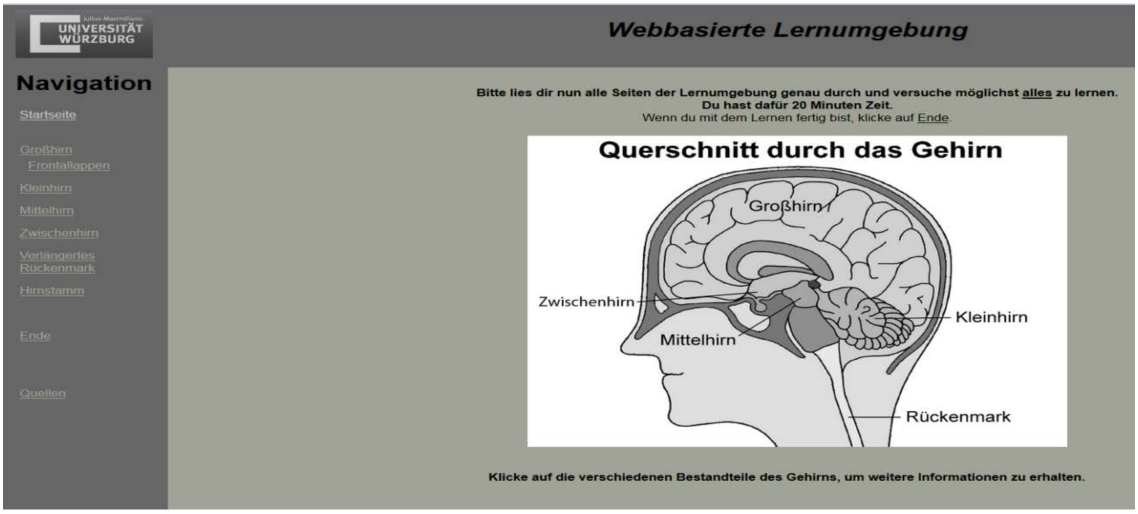

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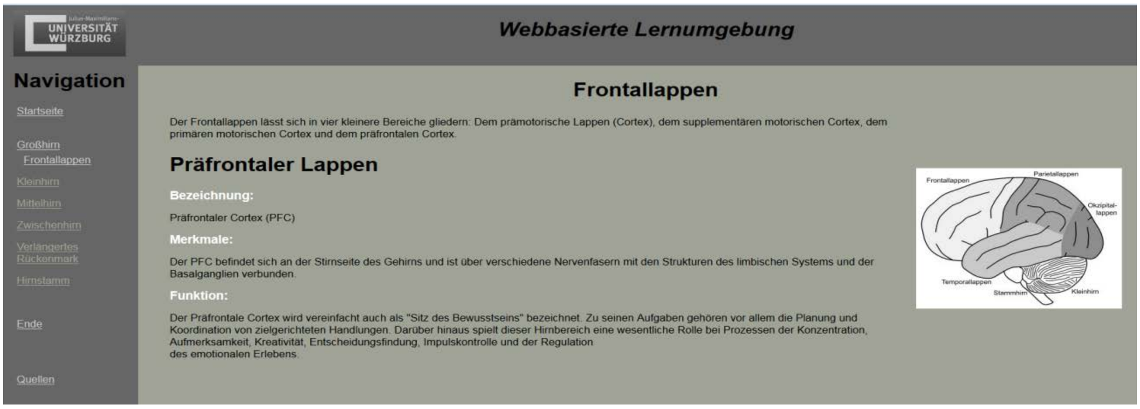

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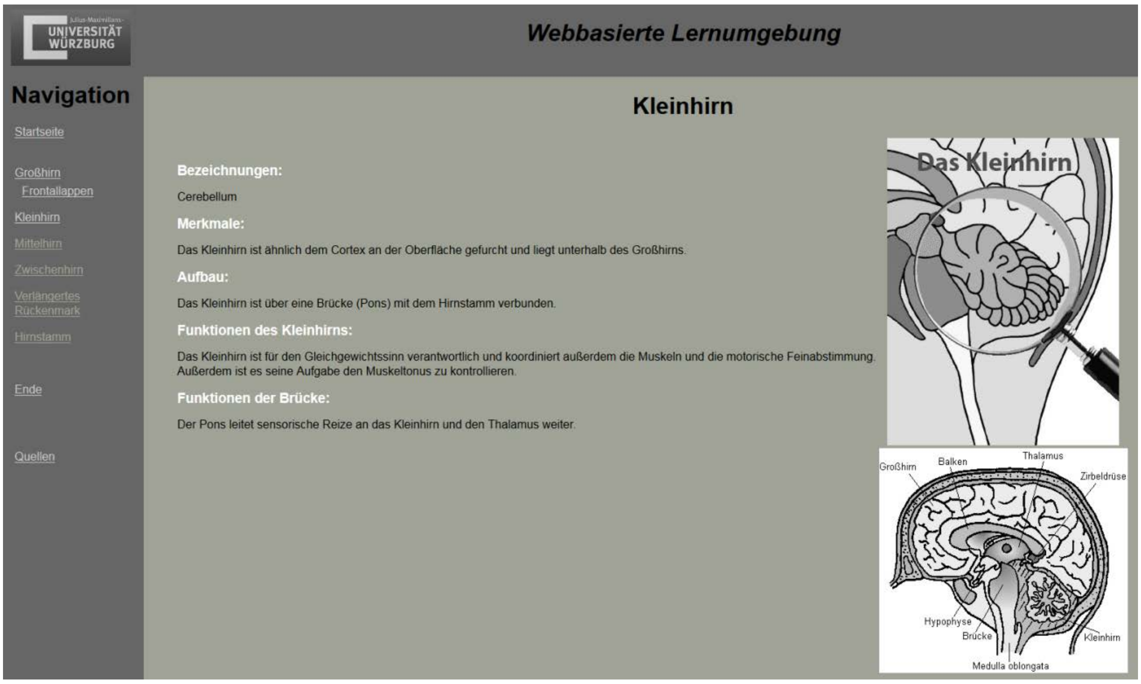

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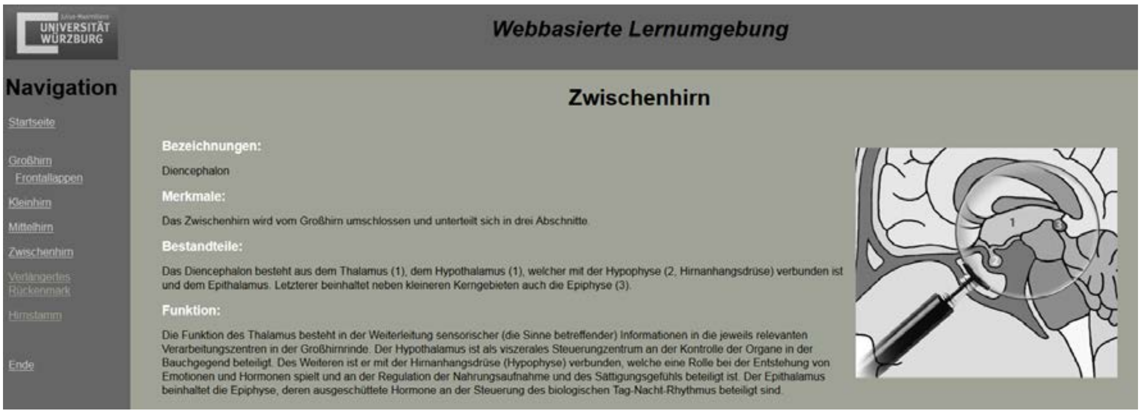

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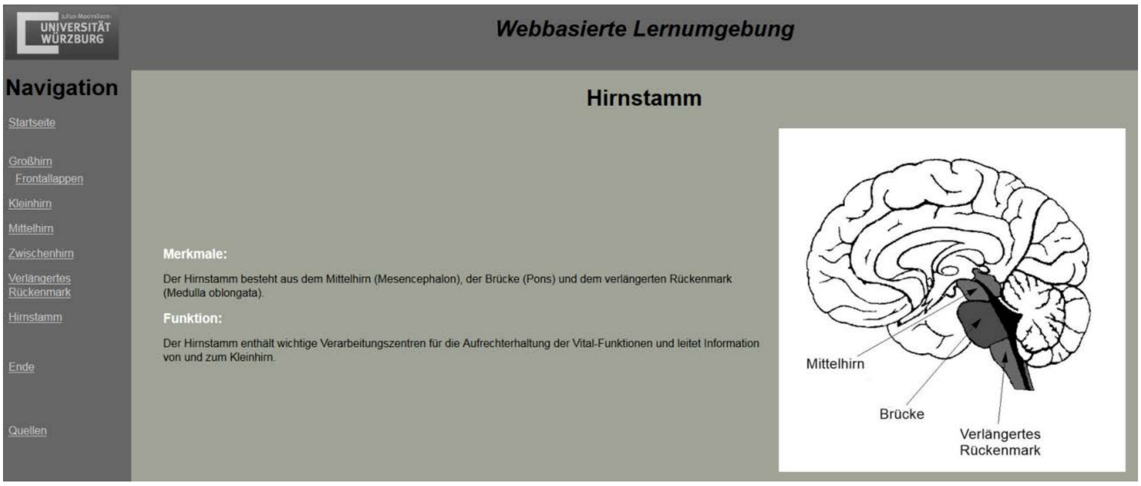
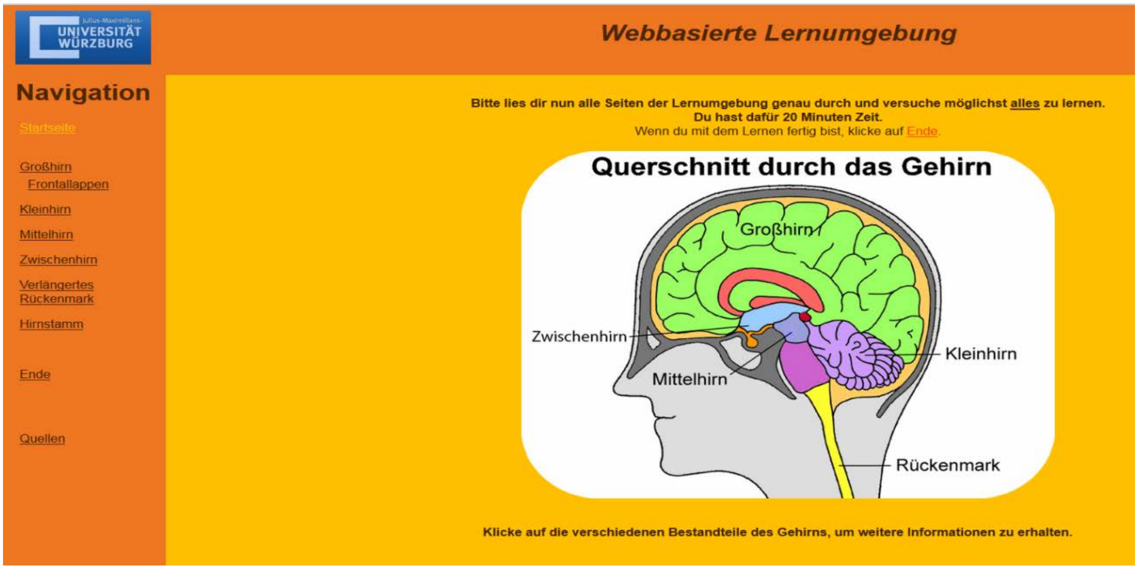


Page 9:

b) Positive Affect Condition:

Page 1:



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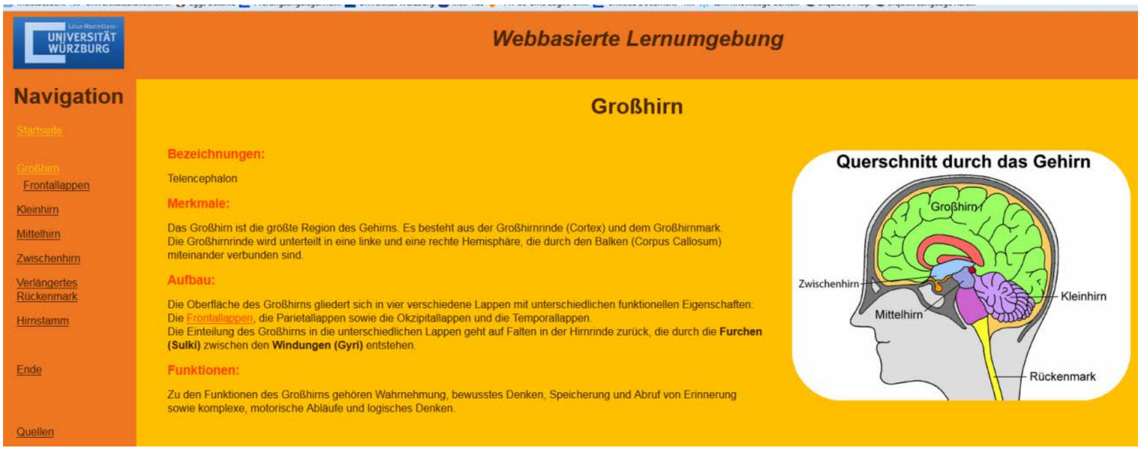

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Appendix A3: Learning Environment used in Experiment 3

a) Control Condition:

Page 1:

Page 2:

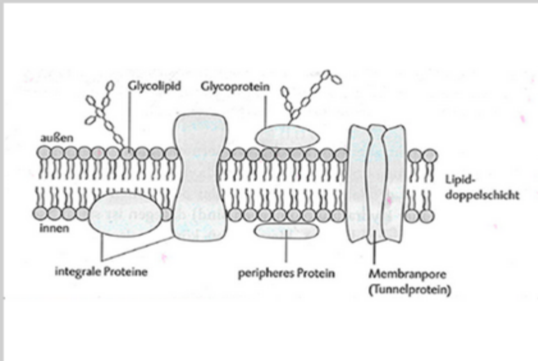
Biomembran

- Startseite
- Biomembran
- Zellkern
- Mitochondrien
- Ribosomen
- Golgi-Apparat
- Endoplasmatisches Retikulum
- Ende
- Quellen

Eine Biomembran ist eine Trennschicht zwischen Zellkompartimenten. Innerhalb der Zelle trennen unterschiedlich aufgebaute Biomembranen das Innere von Organellen oder Vakuolen vom Zytoplasma. Eine Biomembran hat durch Membrankomponenten eine aktive Rolle beim selektiven Transport von Molekülen und der Übermittlung von Informationen zwischen den beiden Kompartimenten, zwischen denen sich diese Biomembran befindet. Diese Unterteilung verschiedener funktionaler Räume innerhalb des Zellplasmas wird daher auch Kompartimentierung genannt. In den so abgegrenzten Reaktionsräumen finden spezielle Stoffwechselaufgaben statt. Auf diese Weise können in der Zelle inkompatible Vorgänge gleichzeitig ablaufen, ohne sich dabei gegenseitig zu stören. Nach außen, als Zellmembran bezeichnet, grenzt die Biomembran die Zelle vom Extrazellularraum ab.

Aufbau der Biomembran

Die Biomembran besteht aus Lipiden und Proteinen. Lipide setzen sich aus einem hydrophilen – dies bedeutet Wasser anziehend – polaren Kopfteil und einem lipophilen - Fett anziehend – unpolaren Schwanzteil zusammen. Bei den Proteinen unterscheidet man zwischen zwei Arten: den peripheren und den integralen Proteinen. Periphere Proteine sitzen nur lose an der äußeren Lipid-Doppelschicht an. Integrale Proteine reichen bis in die Lipidschicht hinein. Lipide und Proteine haben die Fähigkeit Kohlenhydratketten zu tragen.



Aufgaben der Biomembran

Die Biomembran hat verschiedene Aufgaben und Funktionen.

1. Die *Kompartimentierung* – Biomembranen trennen unterschiedliche Reaktions- und Speicherräume (Kompartimente) voneinander ab, wie zum Beispiel die Zellorganellen und Vakuolen mit sehr unterschiedlichen chemischen Zusammensetzungen und Eigenschaften. Da sich die in den Kompartimenten stattfindenden Prozesse durch die Kompartimentierung nicht gegenseitig behindern können, sind sehr unterschiedliche, z.T. sogar gegensätzliche Prozesse zur gleichen Zeit innerhalb einer Zelle möglich.
2. Der *Stofftransport* – Da die Biomembran vor allem eine Trennschicht zwischen verschiedenen Bereichen darstellt, ist sie für die meisten Moleküle undurchlässig. Kleinere lipophile Moleküle können frei durch die Lipiddoppelschicht der Membran diffundieren. Um die Durchlässigkeit der Membran für lipophobe Teilchen wie Wasser, oder große Teilchen wie Ionen oder Zuckermoleküle zu ermöglichen, sind in die Membran verschiedene Transportproteine eingelagert, die für den Transport bestimmter Stoffe zuständig sind. Da die Biomembran also nur bestimmte Stoffe passieren lässt, spricht man von selektiver Permeabilität.
3. *Exozytose* und *Endozytose* – Die Zellmembran ist in der Lage, sich nach innen bzw. nach außen auszustülpen. Dabei wird ein bestimmter Stoff, z.B. ein Protein, von einem Membranbläschen umschlossen. Der umschlossene Stoff kann dann durch die Zelle oder aus dieser heraus transportiert werden und wird am Bestimmungsort wieder abgegeben. Durch diese Vorgänge werden die Abgabe flüssiger Stoffe beziehungsweise die Aufnahme größerer Partikel durch die Membran ermöglicht.
4. Die *Signalübertragung* – Membranproteine nehmen Signale, z.B. elektro-chemische Impulse, auf und geben diese in das Zellinnere weiter.

Endomembransystem

Viele der verschiedenen Membranen in einer eukaryotischen Zelle sind Teile des sogenannten Endomembransystems. Dieses erfüllt in der Zelle eine Reihe unterschiedlicher Aufgaben. Zu diesen Aufgaben zählen beispielsweise die Synthese von Proteinen, ihre Modifikation, der Einbau in Membranen und der Transport zum Bestimmungsort in Organellen oder aus der Zelle heraus, Stoffwechsel und Transport von Lipiden und die Entgiftung toxisch wirkender Stoffe.
Die Membranen des Systems stehen entweder in direktem Kontakt oder sind durch Transportvesikel miteinander verbunden.
Zum Endomembransystem gehören zum Beispiel die Zellkernhülle, das Endoplasmatische Retikulum und der Golgi-Apparat.

Page 3:

Zellkern

Startseite
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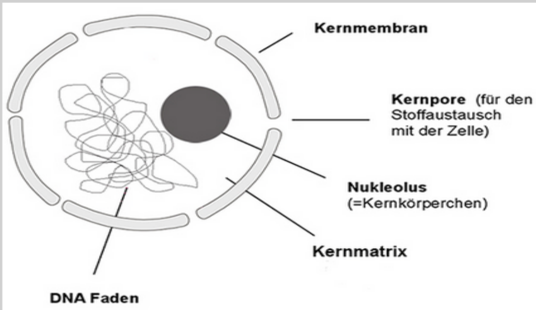
Der Zellkern ist das größte Organell einer eukaryotischen Zelle und ist von einer Doppelmembran umgeben, welche von zahlreichen Kernporen durchbrochen wird. Er erscheint meist eiförmig und farblos. Innerhalb des Zellkerns befindet sich Flüssigkeit, die sogenannte Kernmatrix. In dieser ist DNS – Desoxyribonukleinsäure vorzufinden. Diese ist in Chromosomen – bestehend aus Chromatin – aufgeteilt, die die Grundlage der genetischen Information darstellt. Menschliche Zellen enthalten für gewöhnlich 46 Chromosomen. Ebenfalls im Zellkern zu finden ist der Nukleolus. Dieser besteht aus RNS – Ribonukleinsäure. Im Zellkern befinden sich weitaus die meisten Gene einer eukaryotischen Zelle. Eine geringe Anzahl findet sich dagegen in eigenen Genomen der Mitochondrien und Plastiden.



Aufgaben des Zellkerns

Die DNA im Zellkern enthält einen Großteil der genetischen Information der Zelle. Diese geben Auskunft über den Bau der Zellkomponenten und steuern die Stoffwechselvorgänge, das Wachstum und die Entwicklung der Zellen. Kopien einzelner DNS-Abschnitte sind mithilfe von Botenmolekülen in der Lage, die Kernporen zu passieren und somit den Kern zu verlassen. Dadurch ist die Zelle in der Lage, eine Mitose oder Kernteilung durchzuführen, bei der das Erbgut des Zellkerns repliziert wird. Anschließend kann sich die Zelle so in zwei identische Zellen duplizieren (Zellteilung). Die Kernporen ermöglichen zusätzlich ein beidseitiges Passieren von Makromolekülen in das bzw. aus dem Endoplasmatischen Retikulum. Die Nukleoli sind an der Bildung von Ribosomen beteiligt. Der Zellkern kann also als "Kommandozentrale" der Zelle bezeichnet werden.

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Mitochondrien

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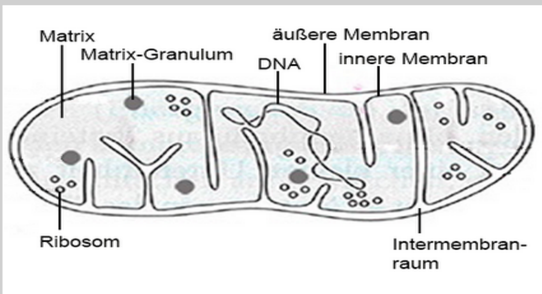
Die Mitochondrien sind überall im Zellplasma verteilt und von einer Doppelmembran umhüllt. Gewöhnlich sind sie bohnenförmig, können jedoch auch rund sein. Die Hülle der Mitochondrien besteht aus einer äußeren und einer inneren Biomembran. Während die äußere Membran das Organell begrenzt, bildet die innere Membran Falten und Fächer die nach innen hin ausgestülpt sind. Diese werden Cristae genannt und vergrößern die Oberfläche der Mitochondrien. Der Raum, der von der Membran umgeben wird, heißt Matrix. In dieser Matrix befinden sich ringförmige DNA-Stücke und kleine Ribosomen. Der Raum zwischen der inneren und der äußeren Membran wird Intermembranraum genannt.



Aufgaben der Mitochondrien

Die Mitochondrien sind für die Zellatmung verantwortlich. Energiereiche, durch die Nahrung aufgenommene Glucose wird hier aerob, das heißt unter Zuhilfenahme von aus der Luft aufgenommenem Sauerstoff, abgebaut. Die freiwerdende Energie wird zur Bildung von ATP – Adenosintriphosphat – verwendet. ATP wird dabei mithilfe von bestimmten Enzymen zwischen der Matrix und dem Intermembranraum gebildet. ATP ist also der Energiespeicher und überträgt Energie in den Zellen. Die Mitochondrien können daher als "Kraftwerke" der Zelle bezeichnet werden.

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Ribosomen

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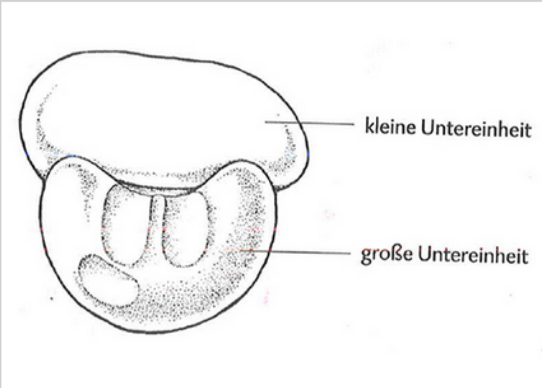
Ribosomen sind kleine Zellorganellen ohne Membran. Sie liegen frei im Zytoplasma oder an Membranen des Endoplasmatischen Retikulums an und sind in eine große Untereinheit und eine kleine Untereinheit eingeteilt. Ribosomen können entweder in dissoziiertem Zustand (beide Untereinheiten sind voneinander getrennt) oder zusammengelagertem Zustand vorliegen. Sie sind kompliziert gebaute Gebilde aus ribosomalen Ribonucleinsäuren (rRNS) und einer Reihe verschiedener Proteine. Die Proteine sind Zellbestandteile, die die Proteinbiosynthese durchführen. Zellen mit hohen Proteinsyntheseraten besitzen eine große Anzahl von Ribosomen. So enthält z.B. eine menschliche Pankreaszelle – Zelle der Bauchspeicheldrüse – einige Millionen Ribosomen.



Aufgaben der Ribosomen

Die Untereinheiten verfolgen verschiedene Aufgaben: Die kleine Untereinheit entschlüsselt die Information der messenger-RNS (mRNS), über welche die genetische Information der Zelle übermittelt wird. Damit können einzelne Eiweißbausteine, sogenannte Aminosäuren hergestellt werden. Die große Untereinheit verknüpft die Aminosäuren schließlich zu langen Ketten, die als Protein bezeichnet werden. Ribosomen sind somit an der Herstellung von langkettigen Eiweißmolekülen beteiligt.

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Golgi-Apparat

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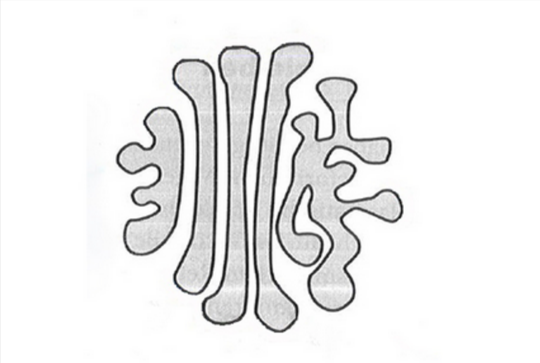
Innerhalb der eukaryotischen Zelle gibt es eine Vielzahl von flachen, scheibenförmigen Reaktionsräumen, die mit einer eigenen Membran umhüllt sind. Ein einzelner dieser Hohlräume wird als Zisterne bezeichnet. Innerhalb der Zelle liegen zumeist vier bis zehn Zisternen stapelförmig aufeinander und sind durch Transportkanäle miteinander verbunden. Einzelne Zellen können meherere Hundert dieser als Dictyosomen bezeichneten Zisternenstapel aufweisen. Die Gesamtheit aller Dictyosomen einer Zelle bildet den sogenannten Golgi-Apparat. Durch die Stapelung sowie die Kanäle durch das ganze Dictyosom können Vorgänge im Golgi-Apparat weitaus schneller ablaufen, als mit nur einem Reaktionsraum. Während sich der Golgi-Apparat bei tierischen Eukaryoten meist in der Nähe des Zellkerns befinden, kann er bei pflanzlichen Eukaryoten auch im Cytoplasma verteilt sein. An seinen Rändern kann der Golgi-Apparat sogenannte Vesikel, kugelförmige von einer einfachen Membran umhüllte Bläschen, bilden und abtrennen. Aufgabe der Vesikel ist der Stofftransport innerhalb der Zelle und zwischen Zellen.



Aufgaben des Golgi-Apparates

Der Golgi-Apparat ist für das Sammeln, Bearbeiten, Lagern, Sortieren, Verpacken und den Transport verschiedener Stoffe verantwortlich. Er arbeitet also sozusagen als das "Zentralpostamt" der Zelle. Transportiert werden zum Beispiel wasserlösliche Eiweiße oder auch Stoffwechselendprodukte. Der Transport und somit die Abgabe oder Aufnahme dieser Stoffe funktioniert über Endo- und Exozytose durch die Vesikel am Rand der Zisternen. Darüber hinaus werden mithilfe des Golgi-Apparates Elemente der Biomembran anderer Zellorganellen synthetisiert. Bei Pflanzenzellen besteht die wichtigste Aufgabe des Golgi-Apparates darin, langkettige Kohlenhydrate für die Zellwand zu produzieren. Da diese in großer Menge benötigt werden, erklärt sich auch die im Vergleich zu Tierzellen deutlich erhöhte Anzahl von Dictyosomen bei pflanzlichen Zellen.

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Endoplasmatisches Retikulum

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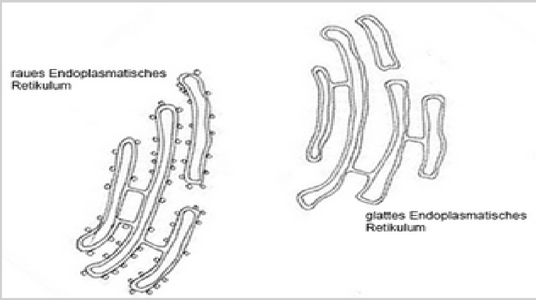
Das Endoplasmatische Retikulum ist ein Netzwerk bestehend aus membranumhüllten Schläuchen und flachen Säckchen, welches in vielen eukaryotischen Zellen mehr als die Hälfte der Gesamtmembran darstellt. Die Schläuche und Säckchen durchziehen das komplette Zytoplasma. Dadurch entsteht eine Verbindung zum Zellkern und den Dictyosomen (Golgi-Apparat). Es wird unterschieden zwischen dem rauen Endoplasmatischem Retikulum (mit Ribosomen besetzt) und dem glatten Endoplasmatischem Retikulum.

Aufgaben des Endoplasmatischen Retikulums

Das Endoplasmatische Retikulum ist für die Bildung von Membranmaterial zuständig. Ähnlich dem Golgi-Apparat fungiert es als "Transportsystem" der Zelle.



Glattes Endoplasmatisches Retikulum

Das glatte Endoplasmatische Retikulum ist an verschiedenen Stoffwechselvorgängen beteiligt, wie z.B. die Synthese von Lipiden, der Kohlenhydratstoffwechsel und die Detoxifizierung von Fremdstoffen, wie Medikamentenwirkstoffe oder Gifte. Das glatte Endoplasmatische Retikulum bildet in Tierzellen bei vielen Wirbeltieren außerdem die Geschlechtshormone.

Raues Endoplasmatisches Retikulum

Viele Zelltypen sondern Sekrete von Proteinen ab, die von am rauen Endoplasmatischen Retikulum verankerten Ribosomen synthetisiert werden. Diese Proteine werden in das Lumen des Organells geschleust. Diese Proteine sind Glycoproteine – sie weisen also gebundene Kohelnhydratketten auf. Die Kohlenhydrate werden im Endoplasmatischen Retikulum und im Golgi-Apparat von speziellen Enzymen angefügt. Allgemein ist das raue Endoplasmatische Retikulum der Syntheseort für neue Membranen. Durch die Einlagerung von Proteinen und Phospholipiden in seine eigene Membran wächst das raue Endoplasmatische Retikulum ständig. Außerdem findet dort auch die Phospholipid-Biosynthese statt. In die Membran eingebettete Enzyme synthetisieren die Phospholipide aus Vorstufen, die im Zellplasma liegen. Innerhalb von speziellen Transportvesikeln (membranumhüllte Bläschen) wandern die Lipide zu anderen Teilen des Endomembranystems.

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Fertig mit Lernen?

Bitte warte auf das Ende der Lernzeit (20 Minuten).
Du kannst dir gerne noch einmal die Lernumgebung ansehen.

b) Positive Affect Condition:

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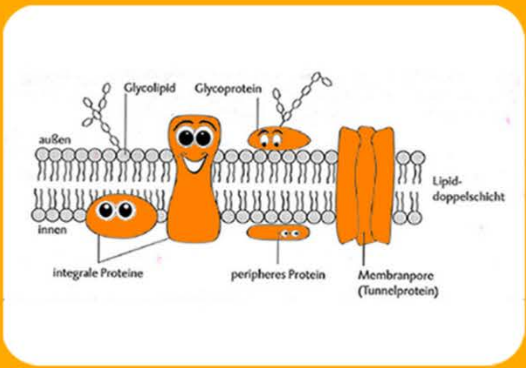
Eine Biomembran ist eine Trennschicht zwischen Zellkompartimenten. Innerhalb der Zelle trennen unterschiedlich aufgebaute Biomembranen das Innere von Organellen oder Vakuolen vom Zytoplasma. Eine Biomembran hat durch Membrankomponenten eine aktive Rolle beim selektiven Transport von Molekülen und der Übermittlung von Informationen zwischen den beiden Kompartimenten, zwischen denen sich diese Biomembran befindet. Diese Unterteilung verschiedener funktionaler Räume innerhalb des Zellplasmas wird daher auch Kompartimentierung genannt. In den so abgegrenzten Reaktionsräumen finden spezielle Stoffwechselaufgaben statt. Auf diese Weise können in der Zelle inkompatible Vorgänge gleichzeitig ablaufen, ohne sich dabei gegenseitig zu stören. Nach außen, als Zellmembran bezeichnet, grenzt die Biomembran die Zelle vom Extrazellularraum ab.

Aufbau der Biomembran

Die Biomembran besteht aus Lipiden und Proteinen. Lipide setzen sich aus einem hydrophilen – dies bedeutet Wasser anziehend – polaren Kopfteil und einem lipophilen - Fett anziehend – unpolaren Schwanzteil zusammen. Bei den Proteinen unterscheidet man zwischen zwei Arten: den peripheren und den integralen Proteinen. Periphere Proteine sitzen nur lose an der äußeren Lipid-Doppelschicht an. Integrale Proteine reichen bis in die Lipidschicht hinein. Lipide und Proteine haben die Fähigkeit Kohlenhydratketten zu tragen.



Aufgaben der Biomembran

Die Biomembran hat verschiedene Aufgaben und Funktionen.

1. Die *Kompartimentierung* – Biomembranen trennen unterschiedliche Reaktions- und Speicherräume (Kompartimente) voneinander ab, wie zum Beispiel die Zellorganellen und Vakuolen mit sehr unterschiedlichen chemischen Zusammensetzungen und Eigenschaften. Da sich die in den Kompartimenten stattfindenden Prozesse durch die Kompartimentierung nicht gegenseitig behindern können, sind sehr unterschiedliche, z.T. sogar gegensätzliche Prozesse zur gleichen Zeit innerhalb einer Zelle möglich.
2. Der *Stofftransport* – Da die Biomembran vor allem eine Trennschicht zwischen verschiedenen Bereichen darstellt, ist sie für die meisten Moleküle undurchlässig. Kleinere lipophile Moleküle können frei durch die Lipiddoppelschicht der Membran diffundieren. Um die Durchlässigkeit der Membran für lipophobe Teilchen wie Wasser, oder große Teilchen wie Ionen oder Zuckermoleküle zu ermöglichen, sind in die Membran verschiedene Transportproteine eingelagert, die für den Transport bestimmter Stoffe zuständig sind. Da die Biomembran also nur bestimmte Stoffe passieren lässt, spricht man von selektiver Permeabilität.
3. *Exozytose* und *Endozytose* – Die Zellmembran ist in der Lage, sich nach innen bzw. nach außen auszustülpen. Dabei wird ein bestimmter Stoff, z.B. ein Protein, von einem Membranbläschen umschlossen. Der umschlossene Stoff kann dann durch die Zelle oder aus dieser heraus transportiert werden und wird am Bestimmungsort wieder abgegeben. Durch diese Vorgänge werden die Abgabe flüssiger Stoffe beziehungsweise die Aufnahme größerer Partikel durch die Membran ermöglicht.
4. Die *Signalübertragung* – Membranproteine nehmen Signale, z.B. elektro-chemische Impulse, auf und geben diese in das Zellinnere weiter.

Endomembransystem

Viele der verschiedenen Membranen in einer eukaryotischen Zelle sind Teile des sogenannten Endomembransystems. Dieses erfüllt in der Zelle eine Reihe unterschiedlicher Aufgaben. Zu diesen Aufgaben zählen beispielsweise die Synthese von Proteinen, ihre Modifikation, der Einbau in Membranen und der Transport zum Bestimmungsort in Organellen oder aus der Zelle heraus, Stoffwechsel und Transport von Lipiden und die Entgiftung toxisch wirkender Stoffe.
Die Membranen des Systems stehen entweder in direktem Kontakt oder sind durch Transportvesikel miteinander verbunden.
Zum Endomembransystem gehören zum Beispiel die Zellkernhülle, das Endoplasmatische Retikulum und der Golgi-Apparat.

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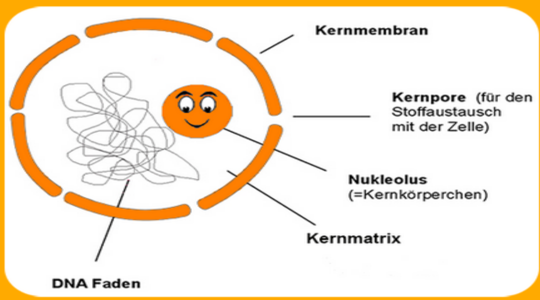
Der Zellkern ist das größte Organell einer eukaryotischen Zelle und ist von einer Doppelmembran umgeben, welche von zahlreichen Kernporen durchbrochen wird. Er erscheint meist eiförmig und farblos. Innerhalb des Zellkerns befindet sich Flüssigkeit, die sogenannte Kernmatrix. In dieser ist DNS – Desoxyribonukleinsäure vorzufinden. Diese ist in Chromosomen – bestehend aus Chromatin – aufgeteilt, die die Grundlage der genetischen Information darstellt. Menschliche Zellen enthalten für gewöhnlich 46 Chromosomen. Ebenfalls im Zellkern zu finden ist der Nukleolus. Dieser besteht aus RNS – Ribonukleinsäure. Im Zellkern befinden sich weitaus die meisten Gene einer eukaryotischen Zelle. Eine geringe Anzahl findet sich dagegen in eigenen Genomen der Mitochondrien und Plastiden.



Aufgaben des Zellkerns

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Mitochondrien

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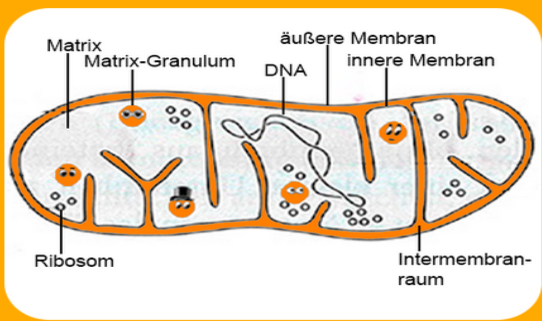
Die Mitochondrien sind überall im Zellplasma verteilt und von einer Doppelmembran umhüllt. Gewöhnlich sind sie bohnenförmig, können jedoch auch rund sein. Die Hülle der Mitochondrien besteht aus einer äußeren und einer inneren Biomembran. Während die äußere Membran das Organell begrenzt, bildet die innere Membran Falten und Fächer die nach innen hin ausgestülpt sind. Diese werden Cristae genannt und vergrößern die Oberfläche der Mitochondrien. Der Raum, der von der Membran umgeben wird, heißt Matrix. In dieser Matrix befinden sich ringförmige DNA-Stücke und kleine Ribosomen. Der Raum zwischen der inneren und der äußeren Membran wird Intermembranraum genannt.



Aufgaben der Mitochondrien

Die Mitochondrien sind für die Zellatmung verantwortlich. Energiereiche, durch die Nahrung aufgenommene Glucose wird hier aerob, das heißt unter Zuhilfenahme von aus der Luft aufgenommenem Sauerstoff, abgebaut. Die freiwerdende Energie wird zur Bildung von ATP – Adenosintriphosphat – verwendet. ATP wird dabei mithilfe von bestimmten Enzymen zwischen der Matrix und dem Intermembranraum gebildet. ATP ist also der Energiespeicher und überträgt Energie in den Zellen. Die Mitochondrien können daher als "Kraftwerke" der Zelle bezeichnet werden.

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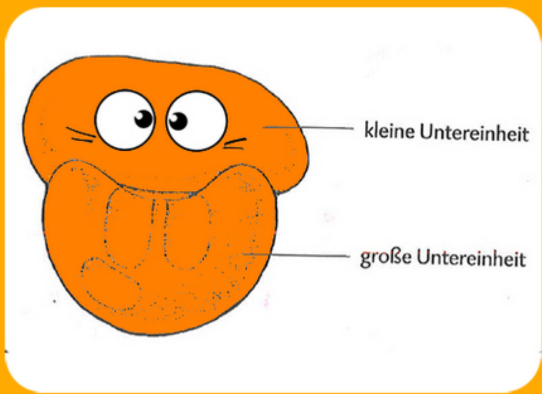
Ribosomen sind kleine Zellorganellen ohne Membran. Sie liegen frei im Zytoplasma oder an Membranen des Endoplasmatischen Retikulums an und sind in eine große Untereinheit und eine kleine Untereinheit eingeteilt. Ribosomen können entweder in dissoziiertem Zustand (beide Untereinheiten sind voneinander getrennt) oder zusammengelagertem Zustand vorliegen. Sie sind kompliziert gebaute Gebilde aus ribosomalen Ribonucleinsäuren (rRNS) und einer Reihe verschiedener Proteine. Die Proteine sind Zellbestandteile, die die Proteinbiosynthese durchführen. Zellen mit hohen Proteinsyntheseraten besitzen eine große Anzahl von Ribosomen. So enthält z.B. eine menschliche Pankreaszelle – Zelle der Bauchspeicheldrüse – einige Millionen Ribosomen.



Aufgaben der Ribosomen

Die Untereinheiten verfolgen verschiedene Aufgaben: Die kleine Untereinheit entschlüsselt die Information der messenger-RNS (mRNS), über welche die genetische Information der Zelle übermittelt wird. Damit können einzelne Eiweißbausteine, sogenannte Aminosäuren hergestellt werden. Die große Untereinheit verknüpft die Aminosäuren schließlich zu langen Ketten, die als Protein bezeichnet werden. Ribosomen sind somit an der Herstellung von langkettigen Eiweißmolekülen beteiligt.

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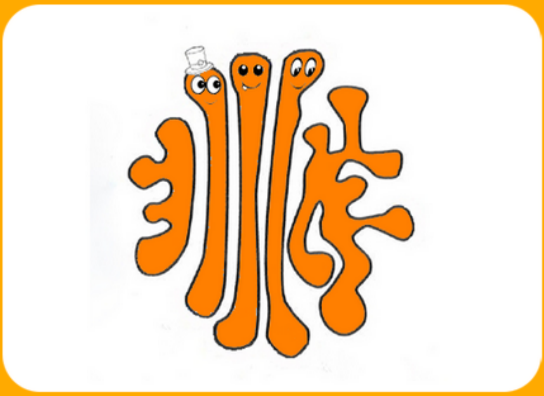

Aufgaben des Golgi-Apparates

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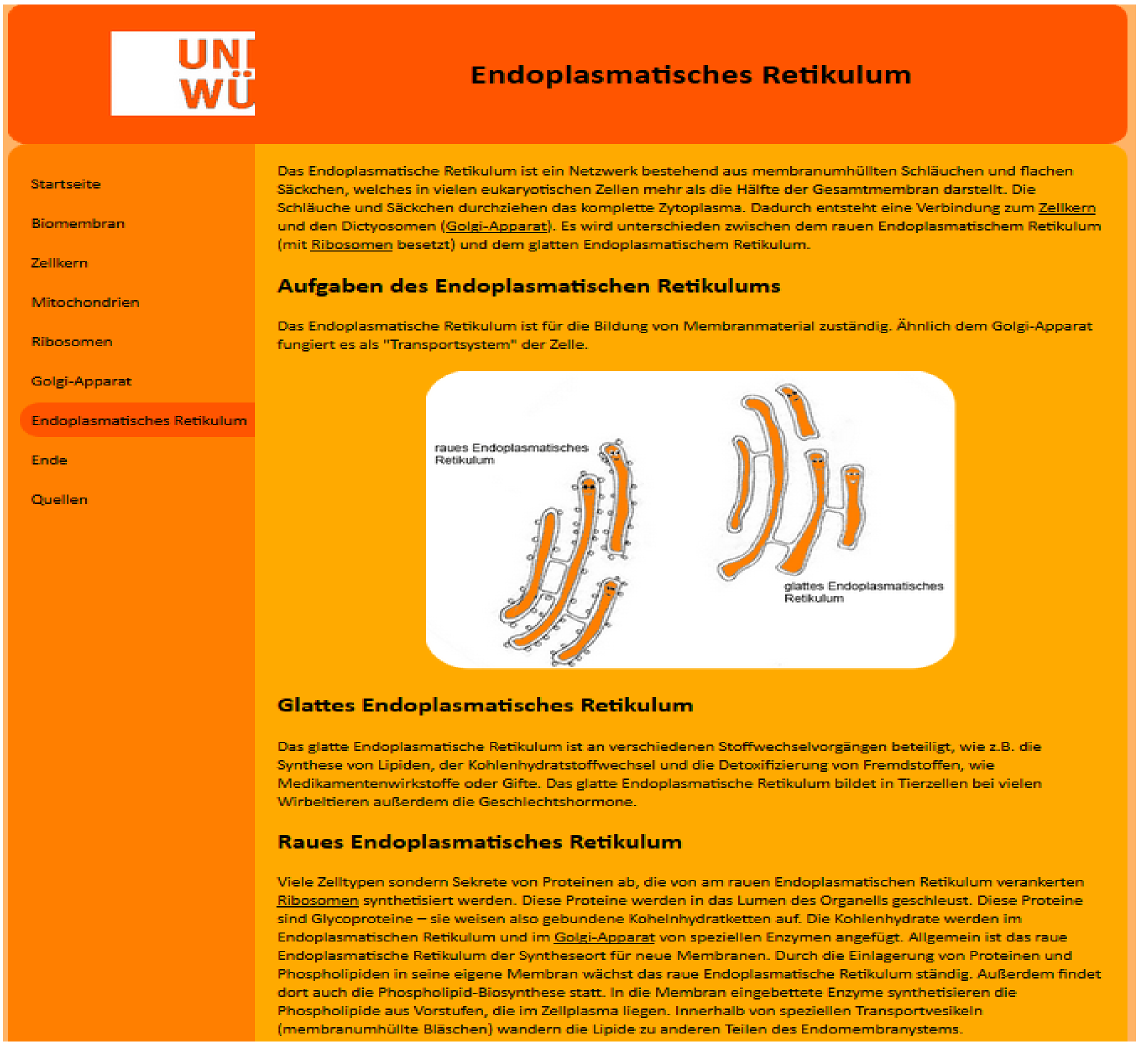

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Endoplasmatisches Retikulum

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Das Endoplasmatische Retikulum ist ein Netzwerk bestehend aus membranumhüllten Schläuchen und flachen Säckchen, welches in vielen eukaryotischen Zellen mehr als die Hälfte der Gesamtmembran darstellt. Die Schläuche und Säckchen durchziehen das komplette Zytoplasma. Dadurch entsteht eine Verbindung zum Zellkern und den Dictyosomen (Golgi-Apparat). Es wird unterschieden zwischen dem rauen Endoplasmatischem Retikulum (mit Ribosomen besetzt) und dem glatten Endoplasmatischem Retikulum.

Aufgaben des Endoplasmatischen Retikulums

Das Endoplasmatische Retikulum ist für die Bildung von Membranmaterial zuständig. Ähnlich dem Golgi-Apparat fungiert es als "Transportsystem" der Zelle.

Glattes Endoplasmatisches Retikulum

Das glatte Endoplasmatische Retikulum ist an verschiedenen Stoffwechselvorgängen beteiligt, wie z.B. die Synthese von Lipiden, der Kohlenhydratstoffwechsel und die Detoxifizierung von Fremdstoffen, wie Medikamentenwirkstoffe oder Gifte. Das glatte Endoplasmatische Retikulum bildet in Tierzellen bei vielen Wirbeltieren außerdem die Geschlechtshormone.

Raues Endoplasmatisches Retikulum

Viele Zelltypen sondern Sekrete von Proteinen ab, die von am rauen Endoplasmatischen Retikulum verankerten Ribosomen synthetisiert werden. Diese Proteine werden in das Lumen des Organells geschleust. Diese Proteine sind Glycoproteine – sie weisen also gebundene Kohelnhydratketten auf. Die Kohlenhydrate werden im Endoplasmatischen Retikulum und im Golgi-Apparat von speziellen Enzymen angefügt. Allgemein ist das raue Endoplasmatische Retikulum der Syntheseort für neue Membranen. Durch die Einlagerung von Proteinen und Phospholipiden in seine eigene Membran wächst das raue Endoplasmatische Retikulum ständig. Außerdem findet dort auch die Phospholipid-Biosynthese statt. In die Membran eingebettete Enzyme synthetisieren die Phospholipide aus Vorstufen, die im Zellplasma liegen. Innerhalb von speziellen Transportvesikeln (membranumhüllte Bläschen) wandern die Lipide zu anderen Teilen des Endomembranystems.

Page 8:

UNI WÜ

Ende

Startseite
Biomembran
Zellkern
Mitochondrien
Ribosomen
Golgi-Apparat
Endoplasmatisches Retikulum
Ende
Quellen

Fertig mit Lernen?

Bitte warte auf das Ende der Lernzeit (20 Minuten).
Du kannst dir gerne noch einmal die Lernumgebung ansehen.

Appendix B: Instructions used in Experiments 1 to 3

Appendix B1: Instructions used in Experiment 1

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0% ausgefüllt

Hallo liebe/r Teilnehmer!

Vielen Dank, dass du an dieser Untersuchung zur Medienwirkung teilnimmst.

Wir gehen der Frage nach, ob Menschen elektronische Texte anders lesen, wenn sie zuvor Medien konsumiert haben.
Wir bitten dich daher, ein kurzes Video anzusehen und dich danach für 20 Minuten mit einer Hypertext-Umgebung zu beschäftigen und danach ein paar Fragen dazu zu beantworten. Bitte versuche, so viel Inhalt wie möglich zu verstehen und dir einzuprägen.

Zuerst möchten wir dich jedoch bitten, ein paar Fragen über dich und deine aktuelle Stimmung zu beantworten. Bitte lies dir alle Aufgabenstellungen am Bildschirm genau durch und versuche bitte alle Fragen ehrlich zu beantworten.

Alle erhobenen Daten werden vertraulich sowie anonym behandelt und nur zum Zweck der Überprüfung der Untersuchungshypothesen verwendet. Eine Weitergabe an Dritte ist ausgeschlossen.

Du kannst die Untersuchung zu jedem Zeitpunkt und ohne Angabe von Gründen abbrechen, indem du den Versuchsleitern ein Handzeichen gibst. Falls du die Untersuchung vorzeitig beendest, werden deine Daten verworfen und nicht weiter ausgewertet.

Du erhälst für die Teilnahme 1 Probandenstunde gutgeschrieben oder kannst an der Verlosung für mehrere Gutscheine teilnehmen.

Weiter

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Vielen Dank, den ersten Teil der Untersuchung hast du nun geschafft!

Du wirst nun zur Hypertext-Umgebung weitergeleitet. Bitte versuche, so viel Inhalt wie möglich zu verstehen und dir einzuprägen.

Klicke bitte auf den Link um zur Hypertextumgebung zu gelangen.

Link zur Hypertextumgebung

Appendix B2: Instructions used in Experiment 2

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oFb - der onlineFragebogen

0% ausgefüllt

Hallo liebe/r Teilnehmer!

Vielen Dank, dass du an dieser Untersuchung teilnimmst.

In dieser Studie wird untersucht, ob Menschen elektronische Texte unterschiedlich lesen. Wir bitten dich daher, dich für 20 Minuten mit einer individuell für dich konzipierten Hypertext-Umgebung zu beschäftigen und danach ein paar Fragen dazu zu beantworten. Bitte versuche, so viel Inhalt wie möglich zu verstehen und dir einzuprägen.

Zuerst möchten wir dich jedoch bitten, ein paar Fragen über dich und deine aktuelle Stimmung zu beantworten. Diese Daten helfen uns, eine für dich individualisierte Hypertext-Umgebung zu generieren.

Bitte lies dir alle Aufgabenstellungen am Bildschirm genau durch und versuche bitte alle Fragen ehrlich zu beantworten.

Alle erhobenen Daten werden vertraulich sowie anonym behandelt und nur zum Zweck der Überprüfung der Untersuchungshypothesen verwendet. Eine Weitergabe an Dritte ist ausgeschlossen.

Du kannst die Untersuchung zu jedem Zeitpunkt und ohne Angabe von Gründen abbrechen, indem du den Versuchsleitern ein Handzeichen gibst. Falls du die Untersuchung vorzeitig beendest, werden deine Daten verworfen und nicht weiter ausgewertet.

Du erhälst für die Teilnahme 1 Probandenstunde gutgeschrieben oder kannst an der Verlosung für mehrere Gutscheine teilnehmen.

Weiter

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Vielen Dank, den ersten Teil der Untersuchung hast du nun geschafft!

Du wirst nun zur Hypertext-Umgebing weitergeleitet. Bitte versuche, so viel Inhalt wie möglich zu verstehen und dir einzuprägen.

Klicke bitte auf den Link um zur Hypertextumgebung zu gelangen.

Link zur Hypertextumgebung

Appendix B3: Instructions used in Experiment 3

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Herzlich Willkommen zu unserer Studie „Happy Learning“!

Vielen Dank, dass du daran teilnimmst.

Im Rahmen der Studie möchten wir untersuchen, wie du dich beim Arbeiten mit einer Hypertext-Umgebung zu einem biologischen Thema fühlst. Dafür bitten wir dich, zu Beginn einige Fragen über dich, deine aktuelle Stimmung und zu deinen Vorkenntnissen zu beantworten.

Anschließend wirst du gebeten, dich für 20 Minuten mit der Hypertext-Umgebung zu beschäftigen und danach ein paar Fragen dazu zu beantworten. Nach etwa zehn Minuten Arbeitszeit wird erneut deine aktuelle Stimmung erfasst.

Bitte lies dir alle Aufgabenstellungen am Bildschirm genau durch und versuche bitte alle Fragen ehrlich zu beantworten.

Alle erhobenen Daten werden vertraulich sowie anonym behandelt und nur zum Zweck der Überprüfung der Untersuchungshypothesen verwendet. Eine Weitergabe an Dritte ist ausgeschlossen.

Du kannst die Untersuchung zu jedem Zeitpunkt und ohne Angabe von Gründen abbrechen, indem du den Versuchsleitern ein Handzeichen gibst. Falls du die Untersuchung vorzeitig beendest, werden deine Daten verworfen und nicht weiter ausgewertet.

Du bekommst für die Teilnahme 1 Probandenstunde im Bereich Instruktionspsychologie und Neue Medien gutgeschrieben oder kannst an der Verlosung für mehrere Gutscheine teilnehmen.

Wenn du noch Fragen hast, stelle diese bitte jetzt. Andernfalls klicke bitte auf weiter und folge den Instruktionen auf dem Bildschirm.

Vielen Dank und viel Spaß!

Weiter

soSci
oFb - der onlineFragebogen

Vielen Dank, den ersten Teil der Untersuchung hast du nun geschafft!

Du wirst nun zur Hypertext-Umgebung weitergeleitet. Bitte versuche, so viel Inhalt wie möglich zu verstehen und dir einzuprägen.

Nach 10 Minuten erscheint ein kurzer Fragebogen, in dem du nach deinen momentanen Empfindungen gefragt wirst. Danach hast du weitere 10 Minuten Zeit, dir den Inhalt einzuprägen

Klicke bitte auf den Link um zur Hypertextumgebung zu gelangen.

Link zur Hypertextumgebung

Appendix C: Learning Tests used in Experiments 1 and 2

Appendix C1: Knowledge Test used in Experiments 1 and 2

Dir werden nun einige Fragen zum Thema der Hypertext-Umgebung gestellt.

Bitte beantworte die folgenden Fragen so gut es dir möglich ist. Es ist immer mindestens eine der vorgeschlagenen Antworten richtig.

1 Welcher dieser Lappen ist Teil der Großhirnrinde?

- ☐ Der Frontallappen
- ☐ Der Parietallappen
- ☐ Der Okzipitallappen
- ☐ Der Temporallappen

2 Unter Sulki und Gyri versteht man…

- ☐ Funktionen des Kleinhirns.
- ☐ Furchen und Windungen im Großhirn.
- ☐ Teile der Brücke, die das Kleinhirn mit Hirnstamm verbindet.
- ☐ Lappen auf der Oberfläche des Großhirns.

3 Wie wird das Großhirn noch genannt?

- ☐ Das Cerebellum
- ☐ Das Mesencephalon
- ☐ Die Medulla oblongata
- ☐ Das Telencephalon

4 An welchen der folgenden Funktionen ist das Großhirn beteiligt?

- ☐ Die Wahrnehmung
- ☐ Der Gleichgewichtssinn
- ☐ Das bewusste Denken
- ☐ Die Speicherung und der Abruf von Erinnerung

5 Welche der Aussagen zu Merkmalen des Kleinhirns sind korrekt?

- ☐ Das Kleinhirn liegt zwischen Hirnstamm und Zwischenhirn
- ☐ Das Kleinhirn ist ähnlich dem Cortex an der Oberfläche gefurcht und liegt unterhalb des Großhirns.
- ☐ Das Kleinhirn ist über eine Brücke (Pons) mit dem Hirnstamm verbunden.
- ☐ Die Kerne des Kleinhirns verarbeiten optische und akustische Reize.

6 Welche der Aussagen zum Hirnstamm sind korrekt?

- ☐ Der Hirnstamm besteht aus dem Mittelhirn, der Brücke und dem verlängerten Rückenmark.
- ☐ Der Hirnstamm wird vom Großhirn umschlossen und unterteilt sich in drei Abschnitte.
- ☐ Der Hirnstamm besteht aus dem Thalamus, dem Hypothalamus und dem Epithalamus
- ☐ Zur Funktion des Hirnstamms gehören Wahrnehmung und bewusstes Denken.

7 Welche der Aussagen zur Medulla oblongata sind korrekt?

- ☐ Die Medulla oblongata verarbeitet optische und akustische Reize.
- ☐ Die Medulla oblongata enthält wichtige Verarbeitungszentren für die Aufrechterhaltung der Vital-Funktionen.
- ☐ Die Medulla oblongata stellt die Verbindung des Rückenmarks mit dem Hirnstamm dar.
- ☐ Die Medulla oblongata kontrolliert autonome Funktionen, wie Herzfrequenz, Blutdruck und Verdauung.

8 Welche Aussage zum Hypothalamus treffen zu?

- ☐ Die Funktion des Hypothalamus besteht in der Weiterleitung sensorischer Informationen in die jeweils relevanten Verarbeitungszentren in der Großhirnrinde.
- ☐ Der Hypothalamus ist als viszerales Steuerungszentrum an der Kontrolle der Organe in der Bauchgegend beteiligt.
- ☐ Der Hypothalamus schüttet Hormone aus, die an der Steuerung des biologischen Tag-Nacht-Rhythmus beteiligt sind.
- ☐ Der Hypothalamus ist mit der Hirnanhangsdrüse verbunden, welche eine Rolle bei der Entstehung von Emotionen und Hormonen spielt.

9 Woran ist die Hypophyse beteiligt?

- ☐ Entstehung von Emotionen und Hormonen
- ☐ Bewusstes Denken
- ☐ Regulation der Nahrungsaufnahme
- ☐ Aufrechterhaltung der Vital-Funktionen

10 Welche der folgenden Hirnareale gehören zum Frontallappen?

- ☐ Der prämotorische Cortex
- ☐ Der supplementär motorische Cortex
- ☐ Der autonome Cortex
- ☐ Der präfrontale Cortex

11 Wie wird der präfrontale Cortex vereinfacht auch bezeichnet?

- ☐ Der Sitz des Gleichgewichtsinns
- ☐ Der Sitz der Motorik
- ☐ Der Sitz des Bewusstseins
- ☐ Der Sitz der Kreativität

12 Zu den Exekutiven Funktionen des präfrontalen Cortex gehören …

- ☐ Die Planung und Koordination von zielgerichteten Handlungen.
- ☐ Die Entscheidungsfindung.
- ☐ Die Regulation des emotionalen Erlebens.
- ☐ Die Kreativität.

Appendix C2: Transfer Test used in Experiments 1 and 2

Nach den vorangegangenen Multiple-Choice Fragen bitten wir dich nun, noch zwei weitere offene Fragen zu beantworten.

Lies dir die Aufgaben aufmerksam durch und versuche die Fragen so gut es geht zu beantworten.

1 Welchen Einfluss kann starker Alkoholkonsum auf das Kleinhirn haben und mit welchen Funktionseinschränkungen ist zu rechnen?

2 Werden bestimmte Gebiete des präfrontalen Cortex in Frontallappen beschädigt (z.B. infolge eines Schädel-Hirn-Traumas), kann es zur Ausbildung des sog. Dysexekutiven Syndroms kommen. Dabei handelt es sich um ein heterogenes Krankheitsbild mit zum Teil sehr unterschiedlichen Symptomen. Ein verhältnismäßig häufig anzutreffendes Merkmal stellt dabei die Störung der Exekutiven Funktionen dar. Beschreiben Sie die konkreten Folgen, die sich aus einem Ausfall dieser Funktionen ergeben.

Appendix D: Learning Tests used in Experiments 3

Appendix D1: (Prior) Knowledge Test used in Experiment 3

Dir werden nun einige Multiple-Choice-Fragen zum Thema der Hypertext-Umgebung gestellt.

Lies dir die Aufgaben aufmerksam durch und setze deine Kreuze so, wie du es für richtig hältst. Es können entweder eine, zwei, drei oder alle der Fragen richtig sein.

1 **Was gehört zu den Eukaryoten?**

- ☐ Archea
- ☐ Pflanzen
- ☐ Tiere
- ☐ Bacteria

2 **Zellmembranen...**

- ☐ ...grenzen die Zelle nach außen hin ab.
- ☐ ...können Teil des Endomembransystems sein.
- ☐ ...dienen der Signalübertragung.
- ☐ ...bestehen aus Lipiden und Proteinen.

3 **Zu den Aufgaben der Biomembran gehört**

- ☐ der Stofftransport
- ☐ die Signalübertragung
- ☐ die Zellatmung
- ☐ die Produktion von Proteinen

4 **Welches dieser Organellen ist das größte innerhalb einer eukaryotischen Zelle?**

- ☐ Endoplasmatisches Retikulum
- ☐ Zellkern
- ☐ Mitochondrien
- ☐ Golgi-Apparat

5 **Die genetische Information in der DNA der Zelle erfüllt mehrere Zwecke. Welche gehören dazu?**

- ☐ Synthese von Phospholipiden
- ☐ Zellwachstum
- ☐ Steuerung der Stoffwechselvorgänge
- ☐ Zellentwicklung

6 In den Mitochondrien...

- ☐ ...wird Glucose abgebaut.
- ☐ ...werden Sekrete von Proteinen abgesondert.
- ☐ ...bildet die Membran Falten und Fächer, die in den Innenraum ragen.
- ☐ ...wird die Gesamtheit von Dictyosomen in der Zelle gebildet.

7 Welche der folgenden Zellorganellen haben eine Membran?

- ☐ Mitochondrien
- ☐ Ribosomen
- ☐ Zellkern
- ☐ Endoplasmatisches Retikulum

8 Welche Aufgaben hat das Endomembransystem?

- ☐ Synthese von Proteinen
- ☐ Bereitstellung des Energiespeichers ATP
- ☐ Stoffwechsel und Transport von Lipiden
- ☐ Kopie von DNA-Abschnitten.

9 Vom Golgi-Apparat werden verschiedene Stoffe...

- ☐ ...gelagert.
- ☐ ...abgebaut.
- ☐ ...sortiert.
- ☐ ...eliminiert.

10 Beim Endoplasmatischen Retikulum unterscheidet man zwischen dem...

- ☐ …geschlossenen und offenen Endoplasmatischen Retikulum.
- ☐ …glatten und rauen Endoplasmatischen Retikulum.
- ☐ …platten und rauen Endoplasmatischen Retikulum.
- ☐ …kurzen und langen Endoplasmatischen Retikulum.

11 Welche Aussagen zu den Ribosomen treffen zu?

- ☐ Sie bestehen aus einer kleinen und einer großen Untereinheit.
- ☐ Sie enthalten für gewöhnlich 46 Chromosomen.
- ☐ Sie befinden sich sowohl frei im Zytoplasma als auch an den Membranen des Endoplasmatischen Retikulums.
- ☐ Sie enthalten Informationen über die Steuerung von Stoffwechselvorgängen.

12 Welche der folgenden Aussagen sind korrekt?

- ☐ Das Chromatin besteht aus Desoxyribonukleinsäure.
- ☐ Das Chromatin besteht aus Ribonukleinsäure.
- ☐ Der Nukleolus besteht aus Desoxyribonukleinsäure.
- ☐ Der Nukleolus besteht aus Ribonukleinsäure.

13 Welche der folgenden Aussagen sind korrekt?

- ☐ Der Golgi-Apparat besteht aus flachen, scheibenförmigen Reaktionsräumen.
- ☐ Die große Untereinheit der Ribosomen entschlüsselt die Information der mRNA.
- ☐ ATP dient als Energiespeicher und überträgt somit Energie in den Zellen.
- ☐ Das Endoplasmatische Retikulum besteht aus gewölbten, kugelförmigen Reaktionsräumen.

14 Endozytose...

- ☐ bedeutet die Abgabe von Stoffen über Vesikel.
- ☐ findet Anwendung im Golgi-Apparat.
- ☐ ermöglicht die Aufnahme größerer Partikel durch die Membran.
- ☐ versorgt die Zelle mit Stoffwechselenergie.

15 Welche Aussagen über Proteine stimmen?

- ☐ Es gibt periphere und integrale Proteine.
- ☐ Sie werden in den Mitochondrien gebildet.
- ☐ Sie bestehen aus Ketten von Eiweißbausteinen.
- ☐ Sie werden auch als Dictysomen der Zelle bezeichnet.

16 Welche Aussagen sind korrekt?

- ☐ Die Unterteilung des Zellplasmas in verschiedene Räume nennt man auch Kompartimentierung.
- ☐ Die Biomembran ist für die meisten Molekühle durchlässig.
- ☐ Membranproteine nehmen elektro-chemische Impulse auf und geben diese in das Zellinnere weiter.
- ☐ Die Zellmembran ist in der Lage sich auszustülpen um Abgabe und Aufnahme von Proteinen zu gewährleisten.

17 Beim Transport von Teilchen durch die Biomembran werden oftmals Transportproteine verwendet. Welche Aussage/n ist/sind korrekt?

- ☐ Die Transportproteine ermöglichen einen schnellen Transport aller Arten von Stoffen.
- ☐ Die Transportproteine funktionieren nach einem Schlüssel-Schloss-Prinzip.
- ☐ Der Transport kleiner lipophiler Stoffe erfolgt von sich heraus.
- ☐ Der Begriff „Selektive Permeabilität“ bedeutet, dass lange Moleküle nicht durch die Biomembran transportiert werden können.

18 Im Gegensatz zu einer eukaryotischen Zelle sind bei einer prokaryotischen Zelle Chromosomen nicht durch einen Zellkern abgegrenzt sondern liegen frei im Cytoplasma. Welche Aussage/n ist/sind richtig?

- ☐ Die Chromosomen einer prokaryotischen Zelle sind nicht durch eine Biomembran umschlossen.
- ☐ Prokaryoten sind nicht zu einer Kernteilung fähig.
- ☐ Prokaryoten besitzen keine DNS.
- ☐ Aufgrund des fehlenden Zellkerns werden keine Botenproteine zum Stofftransport zwischen Chromosomen und Zellorganellen benötigt.

19 Muskelzellen sind für den Bewegungsapparat von Tieren von zentraler Bedeutung, da sie zugeführte Energie in Form von ATP in Muskelarbeit umwandeln. Welche Aussage/n ist/sind korrekt?

- ☐ Muskelzellen sollten möglichst gut von sauerstoffreichem Blut durchflossen werden.
- ☐ Muskelzellen sollten besonders viele Mitochondrien enthalten.
- ☐ Um möglichst viel ATP aufzubauen, sollte keine Glucose aufgenommen werden.
- ☐ ATP kann nur im Zellplasma gebildet werden.

20 Ribosomen erfüllen wichtige Aufgaben bei der Proteinsynthese, d.h. der Herstellung langkettiger Eiweiße. Was ist korrekt?

- ☐ Die Synthese findet innerhalb des Zellkerns statt.
- ☐ Die große Untereinheit transportiert die zur Eiweißsynthese notwendige Erbinformation mittels der mRNS zum Ribosom.
- ☐ Die Translation, das heißt das Ablesen der genetischen Information der mRNS geschieht durch die kleine Untereinheit.
- ☐ Der Transport der Erbinformationen geschieht mithilfe von Botenmolekülen.

21 Was würde geschehen, wenn es keinen Golgi-Apparat gäbe?

- ☐ Endozytose wäre nicht oder nur eingeschränkt möglich.
- ☐ Exozytose wäre nicht oder nur eingeschränkt möglich.
- ☐ Bei Beschädigungen könnten sich die Zellwände und Biomembranen nicht reparieren.
- ☐ Es könnte kein ATP generiert werden.

22 Das Endoplasmatisches Retikulum (ER) ist an einer Vielzahl komplizierter Vorgänge beteiligt. Unter welchen Umständen kann sich ein Organismus glücklich schätzen, ein ER zu besitzen?

- ☐ Wenn Giftstoffe neutralisiert werden müssen.
- ☐ Wenn der Organismus sich fortpflanzen möchte.
- ☐ Bei höheren kognitiven Aufgaben wie z.B. dem planerischen Denken.
- ☐ Bei der Transkription von Erbinformationen.

23 Was zählt zum Endomembransystem?

- ☐ Golgi-Apparat
- ☐ Mitochondrien
- ☐ Endoplasmatisches Retikulum
- ☐ Zellkernhülle.

24 Wie viele Chromosomen enthalten menschliche Zellen für gewöhnlich?

- ☐ 52
- ☐ 60
- ☐ 12
- ☐ 46

Appendix D2: Transfer Test used in Experiment 3

Dir werden nun einige offene Fragen zum Thema der Hypertext-Umgebung gestellt.

Lies dir die Aufgaben aufmerksam durch und versuche die Fragen so gut es geht zu beantworten.

3 Was ist die sogenannte Kompartimentierung und welchen Nutzen hat diese?

4 Beschreiben Sie den Aufbau des Zellkerns und zeigen Sie dabei auf, wo sich hier die genetische Information befindet.

5 Nach der sogenannten Endosymbiontentheorie stammen Mitochondrien von ehemals freilebenden Einzellern ab. Die Theorie besagt ebenfalls, dass frühe eukaryotische Zellen die Mitochondrien aufgenommen haben und somit zur Zellatmung befähigt waren. Nenne und beschreibe den Vorgang, durch den diese Aufnahme möglich war gehört zu den Eukaryoten?

6 In pflanzlichen Zellen sind die sogenannten Chloroplasten für die Bereitstellung von Energie zuständig. Dies geschieht durch die Photosynthese. Hierbei wird Lichtenergie in chemische Energie umgewandelt, mit der energiereiche Glucose aus Kohlenstoffdioxid aufgebaut wird. Nenne das Zellorganell, welches in menschlichen und tierischen Zellen für die Energiebereitstellung zuständig ist und beschreibe diesen Vorgang.

Appendix E: Instruments

Appendix E1: PANAS used in Experiment 1

1. Dieser Fragebogen enthält eine Reihe von Wörtern, die unterschiedliche Gefühle und Empfindungen beschreiben. Lies jedes Wort und trage dann in die Skala neben jedem Wort die Intensität ein, die auf dich zutrifft. Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen. Es gibt hierbei keine richtigen oder falschen Antworten.

Wie fühlst Du Dich im Moment?

	gar nicht				äußerst
aktiv	○	○	○	○	○
bekümmert	○	○	○	○	○
interessiert	○	○	○	○	○
freudig erregt	○	○	○	○	○
verärgert	○	○	○	○	○
stark	○	○	○	○	○
schuldig	○	○	○	○	○
erschrocken	○	○	○	○	○
feindselig	○	○	○	○	○
angeregt	○	○	○	○	○
stolz	○	○	○	○	○
gereizt	○	○	○	○	○
begeistert	○	○	○	○	○
beschämt	○	○	○	○	○
wach	○	○	○	○	○
nervös	○	○	○	○	○
entschlossen	○	○	○	○	○
aufmerksam	○	○	○	○	○
durcheinander	○	○	○	○	○
ängstlich	○	○	○	○	○

Appendix E2: Adapted PANAS used in Experiments 2 and 3

1. Dieser Fragebogen enthält eine Reihe von Wörtern, die unterschiedliche Gefühle und Empfindungen beschreiben. Lies jedes Wort und trage dann in die Skala neben jedem Wort die Intensität ein, die auf dich zutrifft. Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen, benutze hierfür bitte den Schieberegler. Es gibt hierbei keine richtigen oder falschen Antworten.

Klicke auf die Linie, um dein Kreuzchen zu setzen. Anschließend kannst du dieses beliebig nach links und rechts verschieben.

Gib bitte ehrlich an, wie Du Dich in **diesem Moment** fühlst.

	gar nicht	äußerst
aktiv		
bekümmert		
interessiert		
freudig erregt		
verärgert		
stark		
schuldig		
erschrocken		
feindselig		
angeregt		
stolz		
gereizt		
begeistert		
beschämt		
wach		
nervös		
entschlossen		
aufmerksam		
durcheinander		
ängstlich		

Appendix E3: SELLMO used in Experiment 1

1. Im Folgenden werden dir einige Aussagen zu deinen Einstellungen gezeigt. Lies bitte alle Aussagen und entscheide jeweils, wie sehr du der Aussage generell im Studium zustimmst. Bitte beantworte jede Frage ehrlich und denke nicht zu lange über deine Entscheidung nach. Es gibt hierbei keine richtigen oder falschen Antworten.

Im Studium geht es mir darum ...

	trifft überhaupt nicht zu					trifft voll und ganz zu
... neue Ideen zu bekommen.	○	○	○	○	○	○
... zu zeigen, dass ich bei einer Sache gut bin.	○	○	○	○	○	○
... dass andere Studierende nicht denken, ich sei dumm.	○	○	○	○	○	○
... etwas Interessantes zu lernen.	○	○	○	○	○	○
... mich nicht zu blamieren (z.B. durch falsche Ergebnisse oder dumme Fragen)	○	○	○	○	○	○
... später knifflige Probleme lösen zu können.	○	○	○	○	○	○
... Arbeiten besser zu schaffen als andere.	○	○	○	○	○	○
... dass niemand merkt, wenn ich etwas nicht verstehe.	○	○	○	○	○	○
... komplizierte Inhalte zu verstehen.	○	○	○	○	○	○
... bessere Noten oder Beurteilungen zu bekommen als andere.	○	○	○	○	○	○
... dass niemand denkt, ich sei weniger schlau als andere.	○	○	○	○	○	○
... dass das Gelernte für mich Sinn ergibt.	○	○	○	○	○	○
... dass andere denken, dass ich klug bin.	○	○	○	○	○	○
... zu verbergen, dass ich weniger weiß als andere.	○	○	○	○	○	○
... zum Nachdenken angeregt zu werden.	○	○	○	○	○	○
... zu zeigen, dass ich die Inhalte beherrsche.	○	○	○	○	○	○
... keine falschen Antworten auf Fragen der Dozenten zu geben.	○	○	○	○	○	○
... so viel wie möglich zu lernen.	○	○	○	○	○	○
... das was ich kann und weiß auch zu zeigen.	○	○	○	○	○	○
... nicht durch dumme Fragen aufzufallen.	○	○	○	○	○	○
... ein tiefes Verständnis für die Inhalte zu erwerben.	○	○	○	○	○	○
... dass die anderen merken, wenn ich in Tests und Prüfungen gut abschneide.	○	○	○	○	○	○
... nicht zu zeigen, wenn mir eine Aufgabe schwerer fällt, als den anderen.	○	○	○	○	○	○

Appendix E4: Adapted SELLMO used in Experiment 2

1. Im Folgenden werden dir einige Aussagen zu deinen Einstellungen gezeigt. Lies bitte alle Aussagen und entscheide jeweils, wie sehr du der Aussage im Moment zustimmst. Bitte beantworte jede Frage ehrlich und denke nicht zu lange über deine Entscheidung nach. Es gibt hierbei keine richtigen oder falschen Antworten.

Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen, benutze hierfür bitte den Schieberegler. Es gibt hierbei keine richtigen oder falschen Antworten.

Klicke auf die Linie, um dein Kreuzchen zu setzen. Anschließend kannst du dieses beliebig nach links und rechts verschieben.

Im Moment möchte ich ...

	trifft überhaupt nicht zu	trifft voll und ganz zu
...neue Ideen bekommen.		
...zeigen, dass ich bei dieser Aufgabe gut bin.		
..., dass andere Studierende nicht denken, ich sei dumm.		
...etwas Interessantes lernen.		
...mich nicht blamieren.		
...knifflige Probleme lösen können.		
...diese Aufgabe besser schaffen als andere.		
..., dass niemand merkt, wenn ich etwas nicht verstehe.		
...komplizierte Inhalte verstehen.		
...im Test besser abschneiden als andere.		
..., dass andere denken, dass ich klug bin.		
...verbergen, wenn ich weniger weiß als andere.		
...zum Nachdenken angeregt werden.		
...zeigen, dass ich die Inhalte beherrsche.		
...keine falschen Antworten geben.		
...so viel wie möglich lernen.		
...das, was ich kann und weiß auch zeigen.		
...nicht durch dumme Fragen auffallen.		
...nicht zeigen, wenn mir eine Aufgabe schwerer fällt als den anderen.		

Appendix E5: Adapted SELLMO used in Experiment 3

1. Im Folgenden werden dir einige Aussagen zu deinen Einstellungen gezeigt. Lies bitte alle Aussagen und entscheide jeweils, wie sehr du der Aussage generell im Studium zustimmst. Bitte beantworte jede Frage ehrlich und denke nicht zu lange über deine Entscheidung nach. Es gibt hierbei keine richtigen oder falschen Antworten.

Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen, benutze hierfür bitte den Schieberegler. Es gibt hierbei keine richtigen oder falschen Antworten.

Klicke auf die Linie, um dein Kreuzchen zu setzen. Anschließend kannst du dieses beliebig nach links und rechts verschieben.

Im Studium geht es mir darum ...

	trifft überhaupt nicht zu	trifft voll und ganz zu
... neue Ideen zu bekommen.		
... zu zeigen, dass ich bei einer Sache gut bin.		
... dass andere Studierende nicht denken, ich sei dumm.		
... etwas Interessantes zu lernen.		
... mich nicht zu blamieren (z.B. durch falsche Ergebnisse oder dumme Fragen)		
... später knifflige Probleme lösen zu können.		
... Arbeiten besser zu schaffen als andere.		
... dass niemand merkt, wenn ich etwas nicht verstehe.		
... komplizierte Inhalte zu verstehen.		
... bessere Noten oder Beurteilungen zu bekommen als andere.		
... dass niemand denkt, ich sei weniger schlau als andere.		
... dass das Gelernte für mich Sinn ergibt.		
... dass andere denken, dass ich klug bin.		
... zu verbergen, dass ich weniger weiß als andere.		
... zum Nachdenken angeregt zu werden.		
... zu zeigen, dass ich die Inhalte beherrsche.		
... keine falschen Antworten auf Fragen der Dozenten zu geben.		
... so viel wie möglich zu lernen.		
... das was ich kann und weiß auch zu zeigen.		
... nicht durch dumme Fragen aufzufallen.		
... ein tiefes Verständnis für die Inhalte zu erwerben.		
... dass die anderen merken, wenn ich in Tests und Prüfungen gut abschneide.		
... nicht zu zeigen, wenn mir eine Aufgabe schwerer fällt, als den anderen.		

Appendix E6: Adapted FAM used in Experiment 3

1. Nun wollen wir wissen, wie deine momentane Einstellung zur Aufgabe dieser Untersuchung ist. Dazu findest du eine Reihe von Aussagen. Bitte bewerte jeweils, wie sehr die Aussage im Moment auf dich zutrifft.

Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen, benutze hierfür bitte den Schieberegler. Es gibt hierbei keine richtigen oder falschen Antworten.

Klicke auf die Linie, um dein Kreuzchen zu setzen. Anschließend kannst du dieses beliebig nach links und rechts verschieben.

	trifft überhaupt nicht zu	trifft voll und ganz zu
Ich glaube, diese Aufgabe kann jeder schaffen.		
Eine solche Aufgabe würde ich auch in meiner Freizeit bearbeiten.		
Wahrscheinlich werde ich die Aufgabe nicht schaffen.		
Wenn ich an die Aufgabe denke, bin ich etwas beunruhigt.		
Die konkreten Leistungsanforderungen hier lähmen mich.		
Ich glaube, ich schaffe diese Aufgabe nicht.		
Ich fühle mich unter Druck, bei der Aufgabe gut abschneiden zu müssen.		
Ich fürchte mich ein wenig davor, dass ich mich hier blamieren könnte.		
Wenn ich die Aufgabe schaffe, werde ich schon ein wenig stolz auf meine Tüchtigkeit sein.		
Es ist mir etwas peinlich, hier zu versagen.		
Ich mag solche Aufgaben.		
Nach dem Lesen der Instruktion erscheint mir die Aufgabe sehr interessant.		
Ich bin fest entschlossen, mich bei dieser Aufgabe voll anzustrengen.		
Ich glaube, der Schwierigkeit dieser Aufgabe gewachsen zu sein.		
Die Aufgabe ist eine richtige Herausforderung für mich.		
Ich bin sehr gespannt darauf, wie gut ich hier abschneiden werde.		
Bei Aufgaben wie dieser brauche ich keine Belohnung, sie machen mir auch so Spaß.		

Appendix E7: Adapted SEK-27 used in Experiment 3

1. Im Folgenden findest du eine Reihe von AUssagen zu deinem Umgang mit Gefühlen. Bitte bewerte jeweils, wie sehr die Aussage generell auf dich zutrifft.

Du hast die Möglichkeit zwischen verschiedenen Abstufungen zu wählen, benutze hierfür bitte den Schieberegler. Es gibt hierbei keine richtigen oder falschen Antworten.

Klicke auf die Linie, um dein Kreuzchen zu setzen. Anschließend kannst du dieses beliebig nach links und rechts verschieben.

Generell ....

	überhaupt nicht	(fast) immer
... versuche ich, mir in belastenden Situationen selber Mut zu machen.		
... schenke ich meinen Gefühlen Aufmerksamkeit.		
... kann ich positive Gefühle gezielt herbeiführen.		
... stehe ich mir in belastenden Situationen selber zur Seite.		
... kann ich auch negative Gefühle annehmen.		
... verstehe ich meine emotionalen Reaktionen.		
... setze ich mich mit meinen Gefühlen auseinander.		
... ist mir klar, was ich gerade fühle.		
... mache ich, was ich mir vorgenommen habe, auch wenn ich mich dabei unwohl oder ängstlich fühle.		
... kann ich wichtige Ziele verfolgen, auch wenn ich mich dabei manchmal unwohl oder unsicher fühle.		
... weiß ich, was meine Gefühle bedeuten.		
... sind meine körperlichen Reaktionen ein gutes Signal dafür, wie ich mich fühle.		
... fühle ich mich auch intensiven, negativen Gefühlen gewachsen.		
... kann ich zu meinen Gefühlen stehen.		
... akzeptiere ich meine Gefühle.		
... fühle ich mich stark genug, auch belastende Gefühle aushalten zu können.		
... ist mir bewusst, warum ich mich so fühle, wie ich mich fühle.		
... bin ich mir sicher, auch intensive, unangenehme Gefühle aushalten zu können.		
... ist mir klar, dass ich meine Gefühle beeinflussen kann.		
... merke ich gut, wenn mein Körper auf emotional bedeutende Situationen besonders reagiert.		
... kann ich meine negativen Gefühle beeinflussen.		
... kann ich trotz negativer Gefühle das machen, was ich mir vorgenommen habe/hatte.		
... achte ich auf meine Gefühle.		
... kann ich klar benennen, wie ich mich gerade fühle.		
... weiß ich gut, wie es mir gerade geht.		
... habe ich eine gute körperliche Wahrnehmung meiner Gefühle.		
... versuche ich mich in belastenden Situationen selber aufzumuntern.		

Appendix F: Additional Calculations

Appendix F1: Corrected Item-Total Correlations of the SEK-27 subscales used in Experiment 3

Scale	Item	Corr. item-total corr.	Alpha if item deleted	Mean	SD
Attention	... achte ich auf meine Gefühle.	.36	.921	71.41	22.99
	... schenke ich meinen Gefühlen Aufmerksamkeit.	.39	.921	74.46	20.57
	... stehe ich mir in belastenden Situationen selber zur Seite.	.53	.919	66.26	20.87
Regulation	... kann ich positive Gefühle gezielt herbeiführen.	.48	.920	53.14	23.52
	... kann ich meine negativen Gefühle beeinflussen.	.55	.918	54.41	22.15
	... kann ich wichtige Ziele verfolgen, auch wenn ich mich dabei manchmal unwohl fühle.	.51	.919	70.29	18.94
Confrontation	... mache ich, was ich mir vorgenommen habe, auch wenn ich mich dabei unwohl fühle.	.41	.921	60.51	22.75
	... kann ich zu meinen Gefühlen stehen.	.42	.921	65.46	23.89
	... fühle ich mich stark genug, auch belastende Gefühle aushalten zu können.	.62	.917	69.06	22.78
Self-support	... versuche ich, mir in belastenden Situationen selber Mut zu machen.	.44	.920	70.39	20.39
	... weiß ich gut, wie es mir gerade geht.	.65	.917	68.79	20.60
	... bin ich mir sicher, auch intensive, unangenehme Gefühle aushalten zu können.	.60	.918	64.31	24.37
Resilience	... fühle ich mich auch intensiven, negativen Gefühlen gewachsen.	.60	.918	55.38	25.89
	... akzeptiere ich meine Gefühle.	.55	.919	65.41	21.91
	... ist mir bewusst, warum ich mich so fühle, wie ich mich fühle.	.61	.918	66.04	22.67
Acceptance	... kann ich auch negative Gefühle annehmen.	.55	.919	65.12	23.38
	... ist mir klar, dass ich meine Gefühle beeinflussen kann.	.55	.919	64.68	22.00
	... sind meine körperlichen Reaktionen ein gutes Signal dafür, wie ich mich fühle.	.32	.922	68.28	22.65
Understanding	... verstehe ich meine emotionalen Reaktionen.	.57	.918	62.46	25.49
	... weiß ich, was meine Gefühle bedeuten.	.63	.917	65.08	23.29
	... setze ich mich mit meinen Gefühlen auseinander.	.48	.920	69.38	24.46
Body awareness	... habe ich eine gute körperliche Wahrnehmung meiner Gefühle.	.64	.917	67.95	21.79
	... merke ich gut, wenn mein Körper auf emotional bedeutende Situationen reagiert.	.43	.920	75.88	18.39
	... versuche ich mich in belastenden Situationen selber aufzumuntern.	.62	.917	65.78	22.53
Clarity	... kann ich klar benennen, wie ich mich gerade fühle.	.62	.917	59.53	25.36
	... ist mir klar, was ich gerade fühle.	.67	.917	64.34	21.73
	... kann ich trotz negativer Gefühle das machen, was ich mir vorgenommen habe/hatte.	.49	.919	59.52	24.01