Emotion Regulation in Addicted Smokers
(Emotionsregulation bei abhängigen Rauchern)

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I hereby confirm that my thesis entitled "Emotion regulation in addicted smokers" is the result of my own work. I did not receive any help or support from commercial consultants. All sources and / or materials applied are listed and specified in the thesis.

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Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt, die Dissertation "Emotionsregulation bei abhängigen Rauchern" eigenständig, d.h. insbesondere selbständig und ohne Hilfe eines kommerziellen Promotionsberaters, angefertigt und keine anderen als die von mir angegebenen Quellen und Hilfsmittel verwendet zu haben.

Ich erkläre außerdem, dass die Dissertation weder in gleicher noch in ähnlicher Form bereits in einem anderen Prüfungsverfahren vorgelegen hat.

Würzburg, 02. 2013 ____________________

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Summary

Background: Nicotine addiction is the most prevalent type of drug addiction that has been described as a cycle of spiraling dysregulation of the brain reward systems. Imaging studies have shown that nicotine addiction is associated with abnormal function in prefrontal brain regions that are important for cognitive emotion regulation. It was assumed that addicts may perform less well than healthy nonsmokers in cognitive emotion regulation tasks. The primary aims of this thesis were to investigate emotional responses to natural rewards among smokers and nonsmokers and to determine whether smokers differ from nonsmokers in cognitive regulation of positive and negative emotions. To address these aims, two forms of appraisal paradigms (i.e., appraisal frame and reappraisal) were applied to compare changes in emotional responses of smokers with that of nonsmokers as a function of appraisal strategies.

Experiment 1: The aim of the first experiment was to evaluate whether and how appraisal frames preceding positive and negative picture stimuli affect emotional experience and facial expression of individuals. Twenty participants were exposed to 125 pairs of auditory appraisal frames (either neutral or emotional) followed by picture stimuli reflecting five conditions: unpleasant-negative, unpleasant-neutral, pleasant-positive, pleasant-neutral and neutral-neutral. Ratings of valence and arousal as well as facial EMG activity over the corrugator supercilii and the zygomaticus major were measured simultaneously. The results indicated that appraisal frames could alter both subjective emotional experience and facial expressions, irrespective of the valence of the pictorial stimuli. These results suggest and support that appraisal frame is an efficient paradigm in regulation of multi-level emotional responses.

Experiment 2: The second experiment applied the appraisal frame paradigm to investigate how smokers differ from nonsmokers on cognitive emotion regulation. Sixty participants (22 nonsmokers, 19 nondeprived smokers and 19 12-h deprived smokers) completed emotion regulation tasks as described in Experiment 1 while emotional responses were concurrently recorded as reflected by self-ratings and psychophysiological measures (i.e., facial EMG and EEG). The results indicated that there was no group difference on emotional responses to natural rewards. Moreover, nondeprived smokers and deprived smokers performed as well as nonsmokers on the emotion regulation task. The lack of group differences in multiple emotional responses (i.e., self-reports, facial EMG activity and brain EEG activity) suggests that nicotine addicts have no deficit in cognitive emotion regulation of natural rewards via appraisal frames.

Experiment 3: The third experiment aimed to further evaluate smokers' emotion regulation ability by comparing performances of smokers and nonsmokers in a more challenging cognitive task (i.e., reappraisal task). Sixty-five participants (23 nonsmokers, 22 nondeprived smokers and 20 12-h deprived smokers) were instructed to regulate emotions by imagining that the depicted negative or positive scenario would become less negative or less positive over time, respectively. The results showed that nondeprived smokers and deprived smokers responded similarly to emotional pictures and performed as well as nonsmokers in down-regulating positive and negative emotions via the reappraisal strategy. These results indicated that nicotine addicts do not have deficit in emotion regulation using cognitive appraisal strategies.

In sum, the three studies consistently revealed that addicted smokers were capable to regulate emotions via appraisal strategies. This thesis establishes the groundwork for therapeutic use of appraisal instructions to cope with potential self-regulation failures in nicotine addicts.

Zusammenfassung

Hintergrund: Nikotinsucht ist die am weitesten verbreitete Form von Drogenabhängigkeit und wird beschrieben als eine immer stärker werdende Dysregulation des Belohnungssystems im Gehirn. Bildgebende Studien zeigten, dass Nikotinabhängige eine abnormale Funktion der präfrontalen Gehirnregionen aufweisen, die für die kognitive Emotionsregulation von entscheidender Bedeutung sind. Es wurde angenommen, dass Süchtige bei kognitiven Aufgaben zur Emotionsregulation schlechter abschneiden als gesunde Nichtraucher. Vorrangige Ziele dieser Thesis waren die Untersuchung emotionaler Reaktionen auf natürliche, Raucher-irrelevante Stimuli bei Rauchern und Nichtrauchern. Außerdem sollte herausgefunden werden, ob sich Raucher von Nichtrauchern bezüglich ihrer kognitiven Regulation von positiven und negativen Emotionen unterscheiden. Um diese Veränderungen in der emotionalen Reaktion in Abhängigkeit der Interpretationsstrategie vergleichen zu können, wurden zwei Paradigmen zur Einschätzung emotionaler Stimuli eingesetzt: Eine prospektive Interpretationsstrategie des kommenden Stimulus (appraisal frame) und eine retrospektive Interpretationsstrategie nach der Stimuluspräsentation (reappraisal).

Experiment 1: Ziel des ersten Experiments war die Evaluierung ob und wie Interpretationen vor positiven oder negativen Stimulusbildern die emotionale Erfahrung und den Gesichtsausdruck von Personen beeinflussen. 20 Versuchspersonen wurden 125 Paare auditiver Beschreibungen (entweder neutral oder emotional) präsentiert, gefolgt von Stimulusbildern, die zusammen fünf Stimulus-Kategorien bildeten: unangenehm – negativ, unangenehm – neutral, angenehm – positiv, angenehm – neutral und neutral – neutral. Valenz- und Arousal-Ratings wurden abgefragt und die EMG-Aktivität der Gesichtsmuskeln corrugator supercilii und zygomaticus

major wurden zeitgleich aufgenommen. Die Ergebnisse zeigten, dass appraisal frames sowohl emotionale Reaktionen einschließlich subjektiver emotionaler Erfahrungen beeinflussen als auch den Gesichtsausdruck verändern können, unabhängig von der Valenz des Bildstimulus. Dies zeigt und beweist die Effizienz des appraisal frame Paradigmas bei der Regulation von emotionalen Reaktionen auf mehreren Verarbeitungsebenen.

Experiment 2: Das zweite Experiment bezog sich auf das appraisal frame Paradigma und sollte untersuchen wie sich Raucher von Nichtrauchern in ihrer kognitiven Emotionsregulation unterscheiden. 60 Probanden (22 Nichtraucher, 19 Raucher ohne Entzug und 19 Raucher mit 12 Stunden Zigarettenentzug) führten Emotionsregulationsaufgaben wie in Experiment 1 beschrieben aus, während ihre emotionalen Reaktionen ständig über Selbsteinschätzungen und psychophysiologische Messungen aufgenommen wurden (faziales EMG und EEG). Die Ergebnisse zeigten keine Gruppenunterschieden bei den emotionalen Reaktionen auf natürliche Stimuli, ohne Bezug zum Rauchen; Außerdem schnitten Raucher mit und ohne Zigarettenentzug in der Emotionsregulationsaufgabe genauso gut ab wie Nichtraucher. Die gleichen Ergebnisse in allen Gruppen hinsichtlich emotionaler Reaktionen (Selbsteinschätzung, faziale EMG Aktivität und EEG Aktivität) machten deutlich, dass Nikotinabhängige keine Einschränkungen in der kognitiven Emotionsregulation auf natürliche Stimuli mittels Vorbeurteilungen haben.

Experiment 3: Der dritte Versuch wurde durchgeführt, um die Fähigkeiten von Rauchern bei der Emotionsregulation zu untersuchen, indem die Erfolge von Rauchern und Nichtrauchern in einer schwierigeren kognitiven Aufgabe (reappraisal task) verglichen wurden. 65 Versuchspersonen (23 Nichtraucher, 22 Raucher ohne Entzug und 20 Raucher mit 12 Stunden Zigarettenentzug) wurden instruiert ihre Emotionen zu regulieren, indem sie emotionale Bilder mit neutralem Gefühl interpretieren. Die Probanden sollten sich vorstellen, dass die negativen oder positiven Syenarios immer weniger negativ oder weniger positiv werden. Die Ergebnisse stellen heraus, dass Raucher mit und ohne Zigarettenentzug ähnlich auf emotionale Bilder reagierten und ihre positiven und negativen Emotionen mit der reappraisal Strategie genauso gut herunterregulierten wie Nichtraucher.

Zusammenfassend machen die drei Studien deutlich, dass Nikotinabhängige mittels Interpretationsstrategien ihre Emotionen regulieren können. Diese Thesis bilden das Fundament für den therapeutischen Nutzen von Interpretationsstrategien, damit Nikotinabhängige mit potenziellen Selbstregulationsstörungen umgehen können.

1. General introduction

1.1 Nicotine addiction: prevalence of smoking and health risks

According to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR), drug addiction is a mental illness that is characterized by compulsive seeking for drug, impaired control over drug use, and emergence of withdrawal symptoms (American Psychiatric Association, 1994). Nicotine addiction is the most prevalent type of drug addiction. For example, in the U.S., up to 20% of adults smoke (Centers for Disease Control and Prevention, 2011a). In Germany, more than 30% of the population over 15 years old smoke. Globally, an estimated 1.3 billion are smokers, of which around 82% reside in low and middle-income countries (World Health Organization, 2011).

Nicotine addiction via smoking is a risky factor of noncommunicable diseases (NCDs) which are the leading causes of death globally (World Health Organization, 2011). About half of all smokers die from smoking related diseases. Iischemic heart disease, for example, has long been known as the most common cause of death in most Western countries, with 68% of diagnoses attributable to tobacco use among those aged 30-44 (World Health Organization, 2012). In total, smoking kills nearly 6 million people per year with an additional 600.000 dying from the effects of second-hand smoke (Mathers & Loncar, 2006; Oberg, Jaakkola, Woodward, Peruga & Pruss-Ustun, 2011). This sum surpasses even the amount of people killed by HIV/Aids, tuberculosis and malaria combined (World Health Organization, 2012).

Smokers are aware of the deadly results of smoking and the majority of them have tried several times to quit smoking (Al-Yousaf & Karim, 2001; Winickoff, Friebely, Tanski et al., 2009). According to a recent survey, two out of three smokers want to quit and 52.4% of current adult smokers tried to quit within the past year (Centers for Disease Control and Prevention, 2011b). However, the majority (75% to 95%) of smokers relapse after successful intervention for smoking cessation within 6 to 12 months (Ferguson, Bault, Chesterman & Judge, 2005; Garvey, Bliss, Hitchcock, Heinold & Rosner, 1992; Nakajima & Al'absi, 2012).

1.2 Emotion and nicotine addiction

The addictive quality of nicotine, a substance found in tobacco products, makes quitting very difficult for smokers (Bardo, Green, Crooks & Dwoskin, 1999; Stolerman & Jarvis, 1995). Previous studies have divided the addiction processes into a series of stages from smoking for psychosocial motives (i.e., social acceptance) to smoking for the pleasurable feelings produced by nicotine and finally to smoking in order to avoid the aversive withdrawal symptoms (Koob, Sanna & Bloom, 1998; Russell, 1974).

In particular, individuals may start to smoke because of peer group pressure, influence of parents and role models, or curiosity (Denscombe, 2001). Whatever the reason is, the basic processes are similar. When a person puffs a cigarette, nicotine enters the lungs during the act of inhalation. From there, nicotine is distributed into the blood and then transported to the brain (Le Houezec, 2003). Nicotine increases the release of dopamine in the reward system that is primarily made up of structures including the orbital prefrontal cortex (OFC), the ventral tegmental area (VTA), the nucleus accumbens (NA), the ventromedial and lateral nuclei of the hypothalamus, and the amygdala (Haber & Knutson, 2012; Ikemoto, 2010; DiChiara & Imperato, 1988; Pontieri, Tanda, Orzi & DiChiara, 1996). The reward system is the brain pleasure center.

Dopamine is an important neurotransmitter that is mainly produced in this pleasure center: from the ventro-tegmental area (VTA) to the striatal complex in particularly in the nucleus accumbens (NAcc; Everitt & Robbins, 2005; Wise & Rompre, 1989). Dopamine (DA) is released during the processing of rewarding stimuli that have survival values (Schultz, 2010). The more dopamine released, the happier people feel (Nestler, 2005). Conceivably, the pleasurable feeling associated with DA release during smoking may also work as reinforce for the behavior (i.e., smoke). Similar to other drugs, nicotine develops tolerance and consequently a smoker has to smoke more and more cigarettes to achieve the same pleasant feeling. Eventually, a smoker will experience withdrawal symptoms if he attempts to quit smoking, including irritability, restlessness, sleeplessness, anxiety, depression, etc (Russell, 1974; Koob & Le Moal, 2008). From that point on, nicotine hijacks the reward system and the smoker develops dependence on smoking.

Emotions play an important role during the development of nicotine addiction. They are referred to as dispositions to action (Lang, 1995), which involve three levels of responses, namely physiological, behavioral and cognitive-verbal reactions (Dolan, 2002; Lang, 1995). Emotions are often classified into positive and negative categories (Cacioppo & Berntson, 1994; Lang, Bradley & Cuthbert, 1990). Notably, organisms prefer positive emotions and seek those situations that induce them, whereas they avoid situations that may induce negative emotions. The self-medication model proposes that people become dependent on smoking because they anticipated its powerful effect in reducing negative emotions (Khantzian, 1985, 1997). Supportively, previous studies have shown that the expectation to reduce negative emotions and/or to gain positive emotions linked to the nicotine intake motivates smoking behaviors

(Baker, Brandon & Chassin, 2004). In line with this, clinical studies have shown that individuals with mental health disorders, such as depression and anxiety, are more likely to smoke than normal people because they expect to reduce negative emotions and gain relaxation via smoking (Battista, Stewart, Fulton, Steeves, Darredeau & Gavric, 2008; Conzalez et al., 2008; McCabe, Chudzik, Antony Young, Swinson & Zolvensky, 2004; Morrell, Cohen & McChargue, 2010). Furthermore, experimental studies suggest that negative emotions increase smoking craving and smoking behaviors including the initiation of smoking, smoking rates, cigarette puffs and relapse of smoking (Baker, Brandon & Chassin, 2004; Bradley, Garner, Hudson & Mogg, 2007; Conklin & Perkins, 2005; Fucito & Juliano, 2009; Juliano & Brandon, 2002; Nakajima & Al'absi, 2012; Perkins, Kareltz, Gledgowd, Conklin & Sayette ,2010; Shiffman &Waters, 2004).

1.3 Emotion regulation and nicotine addiction

Nicotine addiction has been viewed as an attempt to improve mood (Anda, Williamson & Escobedo, 1990; Dinn, Aycicegi & Harris, 2004;Juliano & Brandon, 2002; Martens & Gilbert, 2008; Patterson, Gritzner & Resnick, 2012; Revell, Warburton & Wesnes, 1985). However, simply having negative emotions or lacking of positive emotions does not cause one to smoke. It is assumed that smokers self-medicate their emotional dysfunctions because they are less efficacious in using emotion regulation strategies. In other words, how the individuals regulate emotions may mediate negative emotions and nicotine addiction.

1.3.1 Self-regulation failure view of addiction

The social psychological/self-regulation failure view describes nicotine addiction as a cycle of spiraling dysregulation of the brain reward systems, which is a network responsible for feeling pleasure (Baumeister & Heatherton, 1996). Initial regulation failure sets up impulsive smoking and adds additional negative emotions, until the large-scale breakdown in self-regulation, which results in compulsive smoking (Baumeister & Heatherton, 1996).

Supportively, neuroimaging studies implicates that nicotine addiction involves deficit in executive (inhibitory) control, working memory and decision making, together with abnormal brain functions in prefrontal brain regions (e.g., dorsal medial PFC and both dorsal and ventral lateral PFC) and basal ganglia circuits (Bechara, Dolan, Denburg et al., 2001; Counotte et al., 2009; Froeliger, Gilbert, & McClernon,2009; Galvan et al., 2011; Goldstein & Volkow, 2002; Goldstein & Volkow, 2011; Lubman, Yucel & Pantelis, 2004; Mathers & Loncar, 2006; Sutherland et al., 2012; Yucel, Lubman, Solowij & Brewer, 2007) which are consistently identified as key players in cognitive emotion regulation (McRae, Hughes, Chopra, et al., 2010; Mocaiber, Sanchez, Pereira, et al., 2011; Moratti, Saugar & Strange, 2011; Ochsner & Gross, 2008; Parvaz, MacNamara, Goldstein & Hajcak, 2012). Bechara proposed that drugs can trigger 'emotional hijacking' as bottom-up, involuntary signals originating from the amygdala and undermine executive function of the PFC regions (Bechara, 2005). Consistently, Jacobson et al. (2007) reported that adolescent smokers showed reduced PFC activation compared to abstinent adolescents. And the extent of diminished PFC activity could be predicted by the history of smoking duration in years (Musso et al., 2007). Moreover, nicotine addicts have been associated with lower prefrontal white matter integrity and prefrontal gray matter damage compared to matched controls (Zhang et al., 2010). Therefore, it is assumable that nicotine addicts may perform less well than healthy nonsmokers in emotion regulation tasks. So far, no study has addressed this issue.

1.3.2 A process model of emotion regulation

Emotion regulation is a critically important ability in our daily lives as we are often confronted with the need to regulate inappropriate emotions that are situation-incongruent. Regulation of emotional responses refers to the way in which humans initiate a new or an alternative emotional response (Ochsner & Gross, 2005). Emotion regulation develops early over the course of infancy and continues to mature during childhood and adolescence (Ochsner & Gross, 2005). The well-developed ability of emotion regulation enables people to behave flexibly and adaptively in their environments, and protects individuals from developing affective disorders (Davidson, 2000; Machado & Bachevalier, 2003).

Gross & Thompson (2007) have developed a process model of emotion regulation (see Figure 1). This model described a cycle of emotion generation processes and corresponding emotion regulation strategies employed during this process. As can be seen from the figure, the dynamic emotion generation involves a set of steps. Firstly, a situation is selected and/or modified. And then the situation is attended to, and appraised in a certain way, which yields to a set of emotional responses. Lastly, feedback from potent emotional responses gives input into a new emotion cycle. Accordingly, five families of emotion regulation strategies can be applied to modify emotions: modifying the situation, shifting attention towards or away from the situation, re-appraising (i.e., interpret) the situation in a different way, or altering emotional responses (e.g., suppressing emotional expressions).

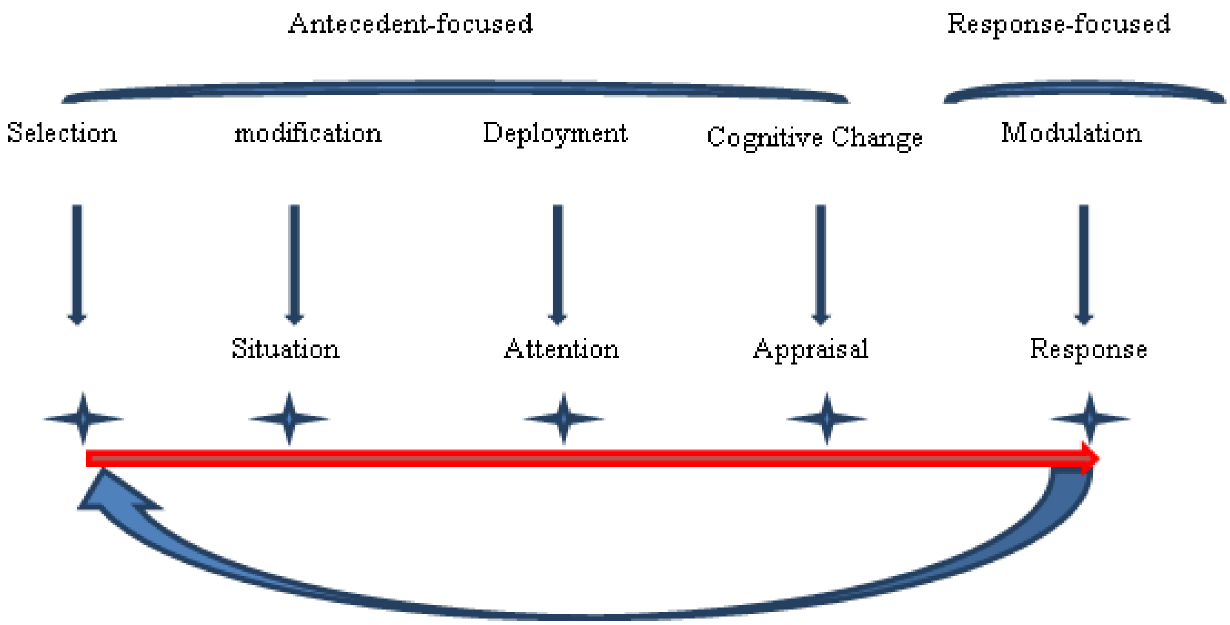


Figure 1. A process model of emotion regulation proposed by Gross & Thompson (2007)

Among those strategies, cognitive change of appraisal has received particular attention in the literature. In fact, previous studies have shown that appraisal strategies are more effective and less costly than others regarding long-term physical health. In other words, appraisal strategies were found to be more positively associated with healthy patterns of affect, cognitive functioning, social interaction, and wellbeing than were other strategies (Ehring et al., 2010; Gross, 1998, 2002; John & Gross, 2004). For example, Richards & Gross (1999; 2000) compared cognitive memory of social information while participants were asked to either reinterpret the social facts or suppress their emotional expressions. The results showed that suppression rather than reappraisal caused impaired memory of social information.

Interestingly, some previous studies have investigated the relation between nicotine addiction and the utility of emotion regulation strategies. The consistent findings are that early smoking initiation, enhanced smoking urges, and failure in smoking abstinence are associated with frequent use of suppression strategies; on the contrary, reduced craving to smoke, greater positive mood, and fewer depressive symptoms are associated with a more frequent use of reappraisal strategies (Baker, Piper, McCarthy, Majeskie & Fiore, 2004; Erskine, Ussher & Cropley, 2012; Fucito & Juliano, 2009; Fucito et al., 2010; Magen & Gross & Thompson, 2007; Szasz, Szentagotai & Hofmann, 2012). Possibly, smokers are less efficacious in using the more adaptive emotion regulation strategies. And in particular it appears that smokers have a deficit in using appraisal strategies to regulate emotions. However, direct empirical support for such impaired ability of smokers to regulate emotions via cognitive appraisal strategies is still lacking.

1.3.3 Emotion regulation paradigms

There are two appraisal paradigms that have been applied to investigate cognitive emotion regulation. One is the reappraisal paradigm, and the other one is the appraisal frame paradigm. Reappraisal refers to the way that a person reinterprets emotional stimuli after an initial appraisal process (Dan-Glauser & Gross, 2011; Gross & Thompson, 2007; Gross, 2002; Hajcak & Nieuwenhuis, 2006; Moser et al., 2010; Ochsner & Gross, 2008; Ray et al., 2010; Urry, 2009). This is a retrospective strategy to alter interpretation of emotional stimuli. In previous studies, participants are exposed to emotional stimuli that are often negative picture stimuli (Gyurak, Gross & Etkin, 2011; Ray, McRae, Ochsner & Gross, 2010) selected from the International Affective Picture System (Lang, Bradley & Cuthbert, 2005). And then, participants reinterpret the negative stimuli from another perspective. Prior work has provided data suggesting that reappraisal is an efficient way to modify emotional responses including emotional experience, expressions and psychophysiology (Gross, 1988, 2002; Gross & Thompson, 2007; Ochsner &

Gross, 2005).

Recent studies about nicotine addiction expanded the findings by applying this paradigm to investigate regulation of smoking craving (i.e., the subjective wanting to use a drug) (Drummond, 2001; Tiffany & Wrary, 2012). Participants were instructed to think about either the short-term pleasant effects or the long-term aversive effects associated with smoking during viewing of smoking-related pictures. The results indicated that smokers reported reduced cravings to smoke when they were asked to think about negative outcomes of smoking a cigarette comparing to when they thought about positive effects of smoking (Kober, Kross, Mischel & Ochsner, 2010; Szasz et al., 2012). It was concluded that smokers are able to apply cognitive reappraisal strategy to regulate their craving to smoke. However, craving differs from emotion in two main aspects. Firstly, craving and emotions may have separable neural substrates (e.g., cingulate cortex, thalamus, and striatum for craving; orbitofrontal cortex, insular cortex, and amygdala for liking) despite some overlapping brain regions (e.g., ventral pallidum, striatum). Secondly, craving and emotion can be altered separately, namely changes in craving are not bound with changes in emotion, and vice versa (Born et al., 2011; Berridge, 1996, 2003; Berridge et al., 2009, 2010; Koob & leMoal, 2008). Therefore, considering these differences between craving and emotions, it is still not clear whether nicotine addicts have deficits in altering emotions via reappraisal strategies, and experimental studies that examine cognitive emotion regulation in nicotine addicts are needed.

Appraisal frames is a prospective form of cognitive emotion regulation, referring to the implementation of orienting narratives to assist a person in changing the intensity of emotional responses to subsequent stimuli (Hajcak & Nieuwenhuis, 2006; Lazarus et al., 1965). In the pioneer studies by Hajcak and his colleagues, participants were exposed to narratives that could influence the meaning of the upcoming stimuli. The electrocortical response and the emotional experience were measured during the viewing of emotional pictures. The results demonstrated that appraisal frames are sufficient to modulate emotional responses as indexed by subjective-ratings and subsequent neural responses (Dennis, Hajcak, 2009; Foti & Hajcak, 2008; MacNamara, Ochsner & Hajcak, 2011; MacNamara, Foti & Hajcak, 2009).

Appraisal frame paradigm differs from reappraisal paradigm in several aspects. The major difference is that appraisal frame paradigm provides participants with detailed orienting narratives, while the reappraisal paradigm offers brief instructions and requires participants to generate their own reinterpretations. And thus, comparing to appraisal frame paradigm, reappraisal paradigm is easier and more convenient for researchers. Most of previous studies in the field of emotion regulation focused on the efficiency of reappraisal paradigm in regulating emotions and investigated its underlying brain mechanisms. In particular, imaging studies have indicated that reappraisal paradigm involves interaction between ventromedial and lateral prefrontal cortex (PFC) which implements cognitive control, and limbic regions which mediate automatic emotional responses (McRae et al., 2010; Ochsner et al., 2002; Ochsner et al., 2004; Ochsner & Gross, 2008; Parvaz et al., 2012). However, few of prior work (with one exception which reported appraisal frames enhanced bilateral activation of the ventrolateral prefrontal cortex and reduced amygdala and insula responses to emotional stimuli, Mocaiber et al., 2011) has examined the interchange between the limbic system and prefrontal cortex (PFC) during emotion regulation via appraisal frames. More research on appraisal frame paradigm is needed.

1.4 Psychophysiological measures

As stated earlier, emotions are dispositions to action that involve multi-level responses (Dolan, 2002; Lang, 1995). Therefore, the effect of appraisal strategies on emotional responses should be detected by the collection of multiple measurements, e.g., self-ratings of emotional state, facial electromyography (EMG), and event-related potentials (ERP).

Self-rating scales have been widely utilized in research because of their ease of use and variability of application. It is the only way to obtain information about individuals' emotional experience. Self-rating scales have been shown to be effective in the assessment of current emotional states (Barrett, 1997; Robinson & Clore, 2002). In the field of emotion and emotion regulation, rating scales like the Self-Assessment Manikin (SAM), which are a series of images, have been widely used to obtain information about subjective emotional states in participants (Bradley & Lang, 2002). Results from studies have shown high levels of reliability and inter-evaluator agreement (Grimm & Kroschel, 2005).

However, some emotions are difficult to quantify, and reporting is sometimes subject to the influence of social demands (i.e., demand characteristics). For example, individuals high in social desirability have been found to be associated with less valid self-reports of emotions, and individuals high in alexithymia seemed to have difficulty in conceptualizing their emotional experiences (Mauss & Robinson, 2009). Therefore, considering the possible influences of demand characteristics on reliability and validity of self-reports, especially in addicts (Fagerstrom, Heatherton, & Kozlowski, 1990), it is suggested that self-rating scales should be combined with methods such as facial EMG and/or ERP that provide automatic and implicit measures of emotional responses.

Among the multiple measures of emotional responses, facial EMG has been considered an effective way of measuring minute and rapid changes in facial expressions, even when the facial movements are not detectible to the eye (Dimberg, 1990; Dimberg & Thunberg, 1998; Likowski, Mühlberger, Gerdes, Wieser, Pauli & Weyers, 2012; Mauss & Robinson, 2009; Gomez, Zimmerman, Guttormsen & Danuser, 2009; Boxtel, 2010; Weyers, Muhlberger, Hefele & Pauli, 2006). The relations between specific facial muscles and emotional valence and intensity were initially demonstrated by Cacioppo in 1986. In his study, participants were exposed to pleasant and unpleasant stimuli in the form of pictorial scenes while the corrugator supercilii, and zygomaticus major were measured for facial EMG activity. It was found that the activation of the corrugator supercilii and zygomaticus major were significantly correlated to emotional valence, with the corrugator supercilii being associated with unpleasantness and the zygomaticus major being associated with pleasantness. A significance of intensity was found for the corrugator supercilii. The results of this experiment played a significant role in laying the framework for the utilization of EMG as an important tool for measuring affective valence and intensity.

To investigate emotion regulation, the measure of EMG has been applied within the context of reappraisal (e.g., Gross & John, 2003; Ray et al., 2010). Given the insights regarding specific muscles and their relationship to emotional valence and intensity, self-reports and EMG were combined to measure the effect of reappraisal on emotional responses. Results demonstrated that participants reported more unpleasant experiences in conjunction with enhanced corrugator activity when negative pictures were re-appraised in a more negative way (Ray et al., 2010). Therefore, facial EMG has been suggested to be a valuable tool in the study of emotion regulation.

Similar to facial EMG, the measure of electroencephalogram (EEG) or ERPs has been shown to be sensitive to emotional reactions (Ibanez et al, 2012). The latter one (i.e., the measure of EEG or ERPs) could be superior, as the measure of EMG has been criticized as obtrusive and the presence of the electrode on the skin may interfere with the natural flow of facial muscle movements (Türker, 1993; Boxtel, 2010). The late positive potential (LPP) is an ERP component that has received particular attention. LPP develops a few hundred milliseconds (i.e., around 300–400 ms) after stimulus onset, peaks around 700ms, and lasts for up to 6s in total (Cuthbert et al., 2000). The amplitude of the LPP is correlated with neural activities in lateral occipital, inferotemporal, and parietal visual areas across picture contents, reflecting perceptional sensitivity to emotional stimuli (Sabatinelli, Lang, Keil & Bradley, 2007). It has been shown that emotionally arousing pictures typically elicit larger LPPs than neutral pictures (Hajcak, Dunning & Foti, 2009; MacNamara & Hajcak, 2009; Sabatinelli, Lang, Keil & Bradley, 2007), in which some studies showing higher LPP amplitudes with positive valence and others showed higher LPP amplitudes with negative valence images (Van Strien, Sonneville & Franken, 2010). This is consistent with findings concerning smokers. In particular, it has been noted that emotional pictures (either positive or negative pictures) evoked larger LPP than neutral pictures in smokers (Versace, Minnix, Robinson, Lam, Brown & Cinciripini, 2010). In the case of emotion regulation, the majority of studies to date focused on regulation of negative emotions, and it has been shown that the amplitude of LPP decreased as a function of regulation strategies like reappraisal (Dennis & Hajcak, 2009; Foti & Hajcak, 2008; Littel & Franken, 2011). However, to my knowledge, no prior work has been done to investigate whether and how smokers' brain activities to emotional pictures are altered by appraisal strategies.

To sum up, emotion regulation involves changes in emotional responses across experiential, behavioral, and physiological systems. Self-rating, facial EMG and EEG have been regarded as valid measures of cognitive emotion regulation among nonsmokers. However, studies that apply those measures to investigate emotion regulation in smokers are scarce.

1.5 Aims and hypothesis

The primary aim of this thesis was to investigate whether smokers are impaired or not in cognitive emotion regulation via appraisal strategies compared to nonsmokers. A collection of multiple measures including self-ratings and psychophysiological responses (i.e., facial EMG, EEG) were applied to evaluate emotional changes of smokers and nonsmokers as a function of cognitive emotion regulation. This thesis is the first to investigate cognitive emotion regulation via appraisal strategies in nicotine addicts. This is an important issue for refining the existing theoretical models of nicotine addiction and for developing smoking cessation treatment. If smokers do have deficits in cognitive emotion regulation, then smoking cessation programs should aim to further enhance smokers' cognitive abilities; otherwise, clinical treatments could just focus on behavioral therapies that change the priority of emotional strategies and increase smokers' habitual use of appraisal strategies.

Theoretical models such as self-regulation failure theory of addiction proposed that continuing failure in emotion regulation plays an important role in development and maintenance of drug addiction. Evidences from clinical studies have noted a close link of nicotine addiction and maladaptive strategies in emotion regulation (Baker, Piper, McCarthy, Majeskie & Fiore, 2004; Fucito et al., 2010; Magen & Gross, 2007; Szasz et al., 2012). Moreover, imaging studies have reported that nicotine addicts are associated with abnormal activities in frontal brain regions (e.g., dorsal medial PFC and both dorsal and ventral laterial PFC: Goldstein& Volkow, 2011; Sutherland et al., 2012; Xu et al., 2007; Zhang et al., 2010), which are important for cognitive emotion regulation (Bechara et al., 1996; Davidson, 2004; McRae, Hughes, Chopra, et al., 2010; Mocaiber, Sanchez, Pereira, et al., 2011; Ochsner and Gross, 2005; Parvaz, MacNamara, Goldstein & Hajcak, 2012).

Therefore, I hypothesized that heavy smokers would have deficit in cognitive emotion regulation compared to nonsmokers. Specifically, it was assumed that when instructed to use appraisal strategies to down-regulate emotions (either positive or negative), smokers would show smaller changes in their emotional responses to emotional stimuli than nonsmokers, as indexed by self-rated emotions, facial EMG activities, and LPP activity.

The second main aim of this thesis was to evaluate the effects of smoking abstinence in cognitive emotion regulation. Some studies have shown that deprived smokers experience more negative emotions and higher cravings to smoke than nondeprived smokers (Dar et al., 2010; Cinciripini et al., 2006). Moreover, it was found that deprived smokers generally do not perform as well on a variety of cognitive tasks as compared to nondeprived smokers, including visual attention (Lawrence et al., 2002), associative processes (Rusted et al. 1998), arousal and vigilance (Gilbert et al. 2004), and affective information processing (Gilbert et al. 2007, 2008). Accordingly, I proposed group differences on emotion regulation tasks, i.e., abstinence of smoking would worsen smokers’ difficulty in cognitive emotion regulation. In particular, comparing to nondeprived smokers, deprived smokers would be less able to apply appraisal strategies to alter emotional experience as indexed by self-ratings and psychophysiological responses as indexed by facial EMG activities and LPP activity.

The third objective was to compare positive emotion regulation and negative emotion regulation between smokers and nonsmokers. Prior work has indicated that it is necessary to regulate positive emotions as well as negative emotions since both categories of emotions have been correlated with functioning in cognitive, affective and social domains (Aldao et al., 2010; Conzelmann et al., 2010; Conzelmann et al., 2011; Fredrickson, 2001; Fredrickson et al., 2008; Geier et al., 2000; Winkler et al., 2011). Imaging studies have demonstrated more similarities than differences between positive and negative emotion regulation. In particular, both forms of emotion regulation have been associated with activation in areas of the prefrontal cortex (Beauregard et al., 2001; Kim and Hamann, 2007; Ochsner et al., 2002, 2004). To my knowledge, none of prior work has investigated regulation of positive emotion in nicotine addicts. To fill in the gap, this thesis compared regulation of both negative and positive emotions in smokers and nonsmokers. It is hypothesized that in comparison with nonsmokers, smokers would be impaired in emotion regulation irrespective of the valence. In other words, smokers would have deficit in regulation of positive emotions as well as negative emotions.

In addition, considering that the emotions can be conceptualized into two main dimensions, valence and arousal, it is interesting to examine how appraisal strategies modify emotional valence and arousal. Prior studies showed that more negative stimuli are consistently coupled with higher arousal ratings; however, this is not the case for positive stimuli, as more positive stimuli may lead to either higher or lower arousal ratings (Lang et al., 2005). Therefore, I hypothesized that during emotion regulation tasks, emotional valence and arousal would be altered consistently with respect to the negative stimuli, but not the positive stimuli. In particular, it is predicted that with regard to negative stimuli, appraisal strategies would synchronously alter emotional valence as indexed by self-rated unpleasantness, facial EMG over corrugator muscle and emotional arousal as indexed by arousal ratings and LPP activity. However, this would not be the same case for positive stimuli.

Finally, this thesis aimed to investigate whether and how cravings to smoke are affected by emotion regulation. Previous studies have noted that craving to smoke is positively correlated with aversive emotions (Dar et al. 2010), and regulation of craving by cognitive strategies in cigarette smokers involved brain regions that are either overlapping with (Kober et al., 2010) or separable from the brain regions for cognitive emotion regulation (Born et al., 2011). So far, no prior work has directly examined correlation between emotion regulation and craving regulation. Here, I investigated whether smokers' self-reported craving to smoke would be changed consistently with emotional responses as reflected in self-rated emotions, facial EMG activities and LPP activities.

A series of experiments were designed to address these issues. The first experiment aimed to test the appraisal frame paradigm that has not been well studied in previous research. The next two experiments applied the appraisal frame paradigm and the reappraisal paradigm respectively to compare how deprived smokers, nondeprived smokers and nonsmokers differ on their emotional responses and smoking cravings as indexed by self-ratings and psychophysiological measures.

2. Experiment 1: Effect of appraisal frames on self-ratings of positive and negative pictures and facial electromyographic activity[1]

2.1 Introduction

It has been recognized that there are two forms of appraisal strategies, one is prospective manipulation of interpretation of emotional stimuli (i.e., appraisal frames) and the other one is retrospective change of the meaning of emotional stimuli after the initial appraisal process (i.e., reappraisal; Wu, Winkler, Andreatta, Hajcak & Pauli, 2012). Appraisal frame paradigm is different from reappraisal paradigm in that participants were provided with orienting narratives rather than being left to generate their own reinterpretations. The appraisal frame paradigm may involve fewer differences in task difficulty across conditions than the reappraisal paradigm. Furthermore, since the narratives were given prior to the presentation of emotional stimuli, the initial emotional response as a function of emotion regulation could be observed during appraisal frame task (Foti & Hajcak, 2008).

Despite the advantages of appraisal frames as stated above, accumulating studies in the field of emotion regulation have focused on the effect of reappraisal on emotional responses (Dan-Glauser & Gross, 2011; Gross & Thompson, 2007; Moser et al., 2010; Ochsner & Gross, 2008; Ray et al., 2010; Hajcak & Nieuwenhuis, 2006; Urry, 2009). However, only a few studies have investigated the effect of appraisal frames on emotional responses (Lazarus et al., 1965;

[1] Experiment 1 describes one of my recently published studies (Wu et al., 2012) that describes if and how appraisal frames affect emotional responses as reflected in self-reported valence and arousal as well as facial electromyographic activity.

Foti & Hajcak, 2008).

In a pioneering work by Lazarus and his colleagues (1965), three types of auditory descriptions of stressful motion film clips were developed to alter the cognitive process of appraisal. One description, called ‘denial’, was made to assure the participants that the frightening sceneries in the film were staged rather than real. Another description, called ‘intellectualization’, stated the frightening sceneries in an analytic, neutral way. The third description, called ‘control’, just gave participants a synopsis of the film. Participants listened one of those descriptions before watching the film. Physiological responses including skin conductance and heart rate were measured during viewing of the film. The results showed that, compared to the control description, both the denial description and intellectualization description led to less of stress responses, including lower skin conductance and lower heart rate.

Hajcak and his colleagues further investigated the effect of appraisal frames of emotional pictures on electrical activity of the brain. Similar to the study by Lazarus et al. (1965), auditory descriptions (i.e., either an emotional or a neutral narrative that describes the content of an emotional picture) were developed to influence subsequent appraisal processes. Consistently, the results showed that neutral appraisal frames (i.e., neutral narratives) preceding emotional pictures are effective in reducing the amplitude of the LPP activity which has been regarded as an efficient index of emotional arousal (Foti & Hajcak, 2008).

Although facial expressions have been recognized as the most common way to communicate emotions, and the alteration of facial expressions is a major outcome of emotion regulation (Buck, 1980; James, 1884; Muhlberge et al., 2010), few studies to date have examined the effects of appraisal frames on facial expression, and even fewer studies have combined measures of facial expression with other measures (e.g., self-report). Facial EMG activity has been shown to be a valid tool for measuring facial expressions. Specifically, it was noted that facial EMG activity recorded over the corrugator supercilii (i.e., frowning muscle) and the zygomaticus major muscle (i.e., smiling muscle) are sensitive to emotional valence: unpleasantness and pleasantness, respectively (Cacioppo et al., 1986, Dimberg, 1990, Lang et al., 1993; Witvliet & Vrana, 1995). Therefore, to testify the efficiency of appraisal frame paradigm before using it to examine emotional regulation in nicotine addicts, the pilot study of this thesis attempts to investigate the effect of appraisal frames on experienced emotion and facial expressions as indexed by facial electromyography (EMG).

In addition, previous studies of appraisal frames have focused exclusively on regulation of negative emotions (Lazarus et al., 1965, Foti & Hajcak, 2008, Dennis & Hajcak, 2009; MacNamara, Foti & Hajcak, 2009). It is unclear if this cognitive strategy alters positive emotions too. Prior work has indicated that the positive emotions are important to mental health and functioning (Fredrickson, 2001; Fredrickson et al., 2008). Furthermore, maladaptive positive emotional responses have been associated with drug addiction which is characterized by dysfunction of reward system (Winkler et al., 2011; Geier et al., 2000). Hence, studies that investigate the impact of appraisal frames on positive emotions would not only extend prior work in the field of emotion regulation, but also have important implications for developing a better understanding of addiction and for develop cognitive psychotherapy.

Therefore, the present study aimed to investigate the effect of appraisal frames of emotional pictures (i.e., positive and negative pictures) on emotional responses as indexed by self-reported ratings of valence and arousal and facial EMG activities. Self-reported valence (i.e., degree of unpleasantness-pleasantness) and arousal (i.e., degree of excitability) as well as facial EMG activities were measured simultaneously. This study would be a first step to set up the stage for the second experiment which would apply the appraisal frame paradigm and emotional picture stimuli to investigate emotion regulation in nicotine addicts. It was hypothesized that both emotional experience (i.e., self-reports) and facial expression (i.e., facial EMG activity) would be modulated by appraisal frames. In particular, (1) compared to negative pictures preceded by neutral narratives, negative pictures preceding negative narratives would evoke less negative and less arousal self-ratings, and would increase corrugator activity; (2) compared to positive pictures preceded by neutral narratives, positive pictures preceded by positive narratives would induce more positive and arousing self-ratings, and would increase zygomaticus activity.

2.2 Method

2.2.1 Participants

In total, 24 right-handed individuals (15 females) participated in this study. Most of them were students from the University of Würzburg. The average age was 25.2 ± 5.9 years (range: 17–41 yrs.). All participants were screened with a demographic questionnaire before testing. All participants reported no hearing problems and normal or corrected to normal visual acuity. Participants were compensated with either money (6 euro/h) or course credit. Four individuals who used illicit drugs during the last 12 months or had a history of psychiatric or neurological disorders were excluded.

2.2.2 Materials

125 pictures (including 25 neutral scenes, 50 positive scenes and 50 negative scenes) were selected from the International Affective Picture System (IAPS; Lang et al., 2005)[2]. Those pictures were representative of most of the stimuli included in the IAPS and depicted events like accidents, mutilations, household objects, people, foods, sports, etc. Each picture of this study was presented with a picture size of 600 × 800 pixels on the computer screen at a viewing distance of 60 cm using Presentation software (Neurobehavioral Systems, Albany, CA).

Neutral narratives, negative narratives, and positive narratives were recorded in advance and were presented binaurally via speakers with a volume of 68dB[3]. 125 neutral narratives were developed, one for each picture (e.g., “This is a poster for an upcoming action movie”). 25 negative narratives were developed for the 25 negative pictures (e.g., “This is a serial killer who has murdered 6 people”). And 25 positive narratives were developed for the 25 positive pictures (e.g., “These happy chimpanzees are laughing”). Half of the positive pictures were preceded by

[2] The three picture categories differed from each other regarding normative valence (M = 5.05, SD = 1.21, for neutral pictures; M = 2.82, SD = 1.64, for negative pictures; M = 7.28, SD = 0.48, for positive pictures) and arousal (M = 2.91, SD = 1.93, for neutral pictures; M = 5.71, SD = 2.16, for negative pictures; M = 5.71, SD = 2.28, for positive pictures).

[3] A list of the pictures and corresponding narratives is provided in the appendix 1; neutral and negative pictures with corresponding narratives are selected from the study done by Foti & Hajcak (2008). Previous studies have indicated that those negative narratives preceding negative pictures evoked greater self-reported unpleasantness and arousal, as well as greater electrocortical response than neutral narratives (Foti & Hajcak, 2008; Dennis & Hajcak, 2009). In the present study, all narratives were prepared in English and then translated into German since all participants were native German speakers.

positive narratives (forming positive-positive condition) and half of the negative pictures were preceded by negative narratives (forming negative-negative condition). All neutral pictures and the other halves of the emotional pictures were preceded by neutral narratives (forming neutral-neutral condition, neutral-positive condition, and neutral-negative condition).

Self-Assessment Manikins (SAM; Lang, 1980; Bradley and Lang, 1994) were used to measure emotional experiences as indexed by self-reported valence and arousal. The SAM is a non-verbal instrument. It consists of five graphic figures representing 9-level ratings for both valence (1 = highly negative, 5 = neutral, 9 = highly positive) and arousal (1 = low arousal, 9 = high arousal).

2.2.3 Procedure and Apparatus

Prior to the experiment, participants read the instructions for the experiment and signed a written consent. They were then guided to sit in a comfortable chair in a sound attenuated and dimly lit room. To decrease demand characteristics, participants were informed that skin conductance was measured when the facial EMG sensors were attached. Any statements relevant to “emotion regulation” and “facial expression” were not mentioned. The formal experimental session started after three practice trials. The experimental session consisted of five experimental conditions (i.e., neutral-neutral, positive-positive, neutral-positive, neutral-negative, and negative-negative) with 25 trials for each condition.

The experimental procedure is depicted in Figure 2. Each trial started with a white fixation cross presented for a period randomly ranging between 4 and 5 sec. The fixation cross turned to blue one second before the onset of the auditory narratives which could last from 2 to 4 sec.

There was a 1 sec delay following each narrative, and then the corresponding picture was presented for 4 sec. At the offset of each picture, the SAM scales appeared on the screen and participants rated how they felt during picture presentation.

In total, there were 125 trials, which were pseudorandomized so that no more than three trials from the same condition were presented successively. Participants could take a short break after every 25 trials. The whole experimental session lasted about 40 minutes.

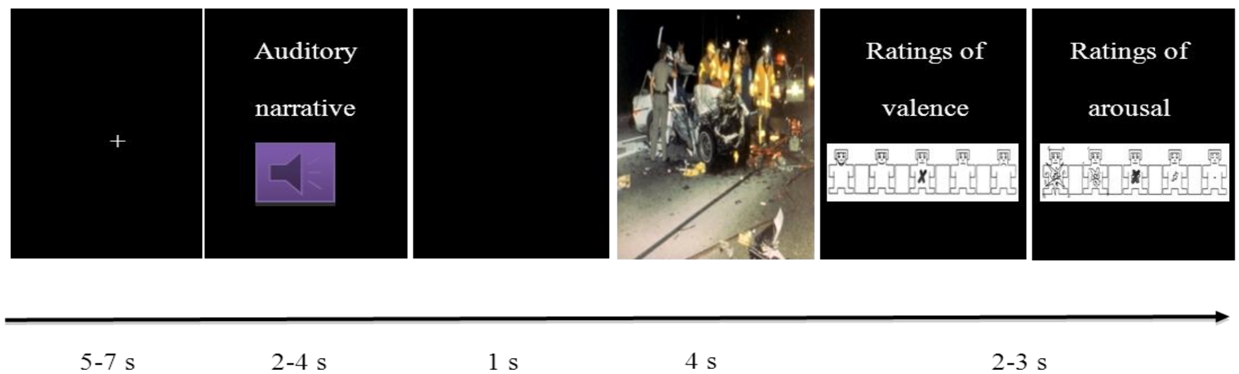


Figure 2. An example of one trial for the Experimental 1.

2.2.4 Psychophysiological data recording

To measure facial electromyographic (EMG) activity, two pairs of Ag/AgCl electrodes with a surface diameter of 7mm were placed over the left eye (corrugator) and left cheek (zygomaticus) according to guidelines provided by Fridlund and Cacioppo (1986). A reference electrode was placed on the forehead and a ground electrode on the left mastoid. The usage of an additional reference electrode was determined by the type of amplifier which uses one common reference for each recording channel (two channels for each muscle). EMG activity was acquired continuously at 1000 Hz with a V-Amp 16 amplifier (Brain Products Inc.). Before electrode placement, sites were swabbed with an alcohol prep pad and then gently abraded using a skin preparation paste. Impedance was kept below 10 kΩ.

2.2.5 Data Reduction

Off-line analyses of the EMG activity were conducted with Brain Vision Analyzer Software (Version 2.0, Brain Products Inc.). The electrodes were re-referenced to obtain bipolar recordings. The raw signal was filtered with a band-pass filter from 30 Hz to 500 Hz and a 50 Hz notch filter. And then the data was rectified and smoothed using a 125 ms moving average filter. Subsequently trials with an EMG activity above 8 μV or below -8 μV during the baseline (i.e., one second preceding the onset of picture) and above 30 μV or below -30 μV during picture presentation were excluded. EMG activity was measured as the difference between the mean activity during the 1 sec baseline and the 4 sec picture period. The corrugator activity and zygomaticus activity were scored as the average activity during the time window 300–4000 ms after picture onset over the corrugator supercilii and zygomaticus major muscle respectively.

Self-reports and EMG activity were collapsed over the 25 trials for each condition per participant. Difference scores were calculated by subtracting data scores of the neutral condition (i.e., neutral narratives preceding neutral pictures) from other conditions (i.e., negative-negative, positive-positive, neutral-negative, neutral-positive) and further analyzed.

2.2.6 Statistical analyses

The difference scores were submitted to repeated analyses of variance (ANOVA) with picture valence (positive, negative) and appraisal frame (neutral, emotion consistent) as within-subject factors. Paired *t*-tests were conducted to further examine significant effects[4]. For corrugator and zygomaticus activity, however, I first performed a priori tests based on the following specific hypotheses: for corrugator activity, I expected enhanced activity in the negative-negative compared to the neutral-negative condition; for zygomaticus activity, I expected enhanced activity in the positive-positive compared to the neutral-positive condition. I did not expect effects of negative and positive emotions and their regulation on zygomaticus and corrugator activity, respectively, and although this null hypothesis cannot be tested. I exploratively performed *t*-tests comparing these conditions.

For all analyses the alpha-level was set at .05. The Greenhouse–Geisser correction was applied when the assumption of sphericity was violated. The uncorrected degrees of freedom and effect sizes (partial eta-squared, η^2_p) are reported.

2.3 Results

Mean changes in self-reports and EMG activity depending on emotion conditions are depicted in Figure 3.

2.3.1 Effect of appraisal frame on self-reported valence and arousal

Self-reported valence. The ANOVA revealed main effects of appraisal frame (F (1, 19) = 6.69, p < .05, η^2_p = .26) and picture valence (F (1, 19) = 151.42, p < .01, η^2_p = .89), and an interaction effect of picture valence by appraisal frame (F (1, 19) = 64.46, p < .01, η^2_p = .77). Follow-up *t*-tests revealed that the negative-negative condition was rated as more negative than

[4] All *p* values of the paired t-tests are one– tailed.

the neutral-negative condition (t (19) = 7.75, p < .01), and the positive-positive condition was rated as more positive than the neutral-positive condition (t (19) = -4.07, p < .01).

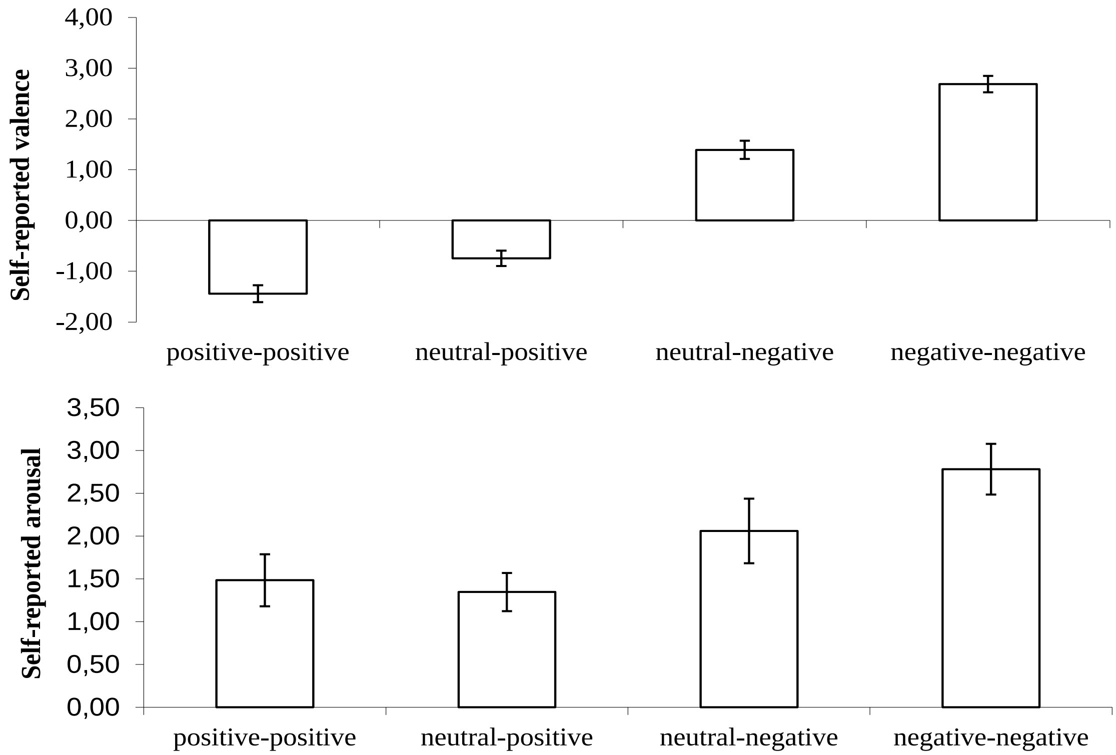
Self-reported arousal. The ANOVA revealed main effects of appraisal frame (F (1, 19) = 9.34, p < .01, η^2_p = .33), of picture valence (F (1, 19) = 28.13, p < .01, η^2_p = .60), and an interaction effect of picture valence by appraisal frame (F (1, 19) = 4.70, p < .01, η^2_p = .20). Follow-up *t*-tests revealed that the negative-negative condition was rated as more arousing than the neutral-negative condition (t (19) = 1.86, p < .01). However, there was no reliable difference between positive-positive and neutral-positive conditions (t (19) = 0.58, p = .57).

2.3.2 Effect of appraisal frame on facial EMG activity

Corrugator activity. The a priori *t*-tests showed that corrugator activity was higher in the negative-negative condition compared to the neutral-negative condition (t (19) = 1.86, p < .05). The a priori comparison of the corrugator activity between the positive-positive and neutral-positive conditions failed to reach statistical significance (t (19) = -0.72, p = .24). The ANOVA revealed a significant main effect of picture valence (F (1, 19) = 28.86, p < .01, η^2_p = .60), but no main effect of appraisal frame (F (1, 19) = 0.75, p = .40, η^2_p = .04). The interaction effect of picture valence by appraisal frame failed to reach the significance level (F (1, 19) = 3.34, p = .08, η^2_p = .15).

Zygomaticus activity. The a priori *t*-tests revealed that zygomaticus activity was larger in the positive-positive condition compared to the neutral-positive condition (t (19) = 1.82, p < .05). The exploratory comparison of the negative-negative and the neutral-negative conditions was not significant (t (19) = -0.35, p = .37). The ANOVA revealed neither significant main effects (picture valence: F (1, 19) = 2.97, p = .10, η^2_p = .14; appraisal frame: F (1, 19) = 1.68, p

= .21, η^2_p = .08) nor a significant interaction of picture valence by appraisal frame (F (1, 19) = 2.47, p = .13, η^2_p = .12).



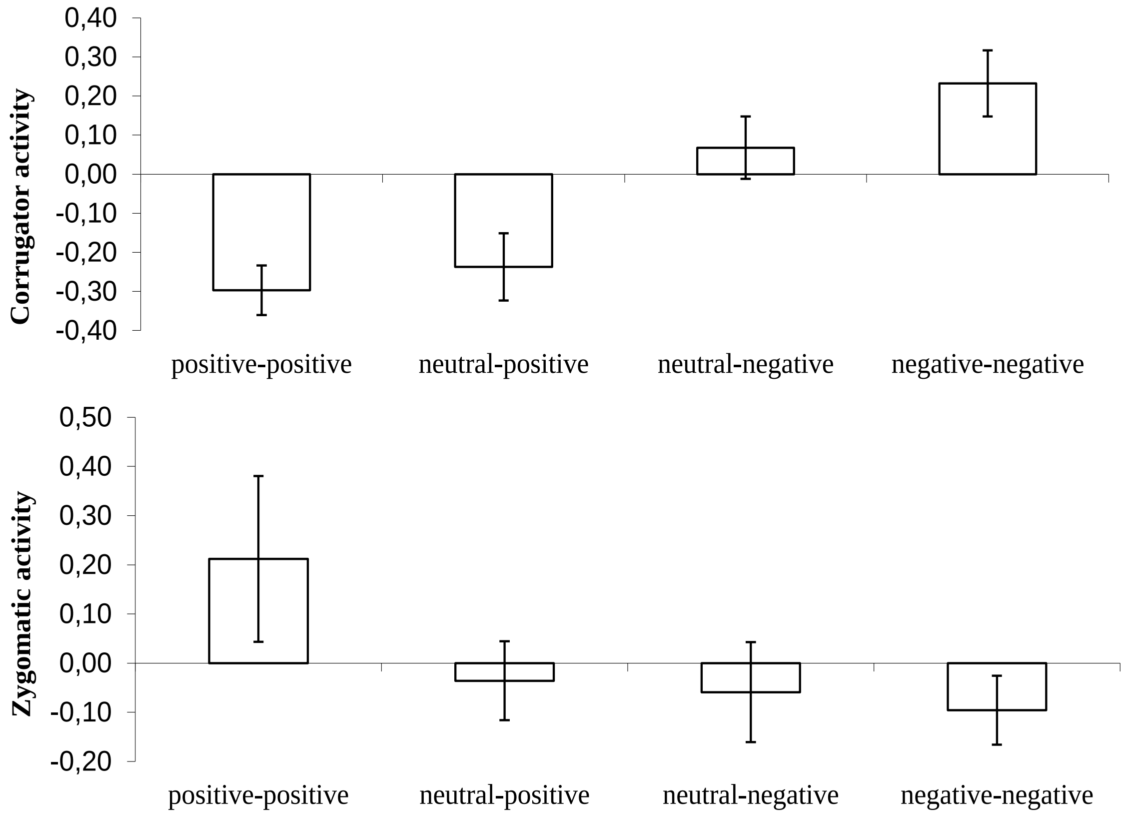


Figure 3. A. Effect of appraisal frames on self-reported ratings of valence and arousal. Depicted are changes in self-reported valence (top) and self-reported arousal (bottom) as a result of appraisal frame. B. Effect of appraisal frames on facial EMG. Depicted are changes in facial EMG activity over corrugator supercilii (top) and zygomaticus major (bottom) as a function of appraisal frame. Each bar represents the difference score between one of the four conditions (positive-positive, neutral-positive, neutral-negative, and negative-negative) and the neutral-neutral condition. Error bars represent standard error of the mean (SEM).

2.4 Discussion

The findings of this study supported my initial assumption that both emotional experiences (i.e., self-reported valence and arousal) and facial expression (i.e., EMG activity over corrugator supercilii and zygomaticus major) triggered by positive or by negative pictures can be altered by appraisal frames.

First, this study extends the emotion regulation literature by showing that appraisal frame preceding negative events may effectively modulate both emotional experience and facial expression. In particular, compared to neutral appraisal frames (i.e., neutral-negative condition), negative appraisal frames preceding negative pictures (i.e., negative-negative condition) increased the self-reported unpleasantness, and the self-reported arousal as well as corrugator activity. These results support previous studies that have indicated an effect of appraisal frame on emotional experience, physiological responses (e.g., heart rate and skin conductance) and/or electrocortical responses (Dennis & Hajcak, 2009; Lazarus, et al., 1965; Gross & D'Ambrosio, 2004; Foti & Hajcak, 2008; MacNamara et al., 2009).

Second, this study investigated the effects of appraisal frames on positive stimuli, which is a critical extension of recent publications on cognitive regulation of positive emotions (Delgado et al., 2008; Giuliani et al., 2008; Krompinger et al., 2008). The results of this study demonstrated that compared to neutral appraisal frames (i.e., neutral-positive condition), positive appraisal frames preceding positive pictures (i.e., positive-positive condition) enhanced pleasantness as reflected in self-reported pleasantness and increased activity over the zygomaticus major muscle. Combining these results with the observed impact of appraisal frames on negative emotions, it is concluded that the effect of appraisal frames may not be valence-specific. In other words, appraisal frames could be applied not only to modulate negative emotions but also to alter positive emotions.

However, appraisal frames preceding positive pictures did not affect self-reported arousal. This finding may suggest a valence-specific effect of appraisal frames on emotional arousal. However, this result may also be related to differences between positive and negative pictures on actual arousal level. Although we had carefully matched the IAPS arousal scores of the two categories of emotional pictures, positive pictures in general were rated as less arousing than negative pictures. It will be interesting for future studies to address this issue by examining the cognitive and neural mechanisms underlying the regulation of positive and negative emotions depending on their arousal level.

Finally, this study replicates and further extends prior work indicating that negative stimuli evoke mainly activity over the corrugator supercilii muscle while positive stimuli evoke mainly zygomaticus muscle activity (Cacioppo, et al., 1986; Lang, et al., 1993). The results of this study suggest that regulation of negative or positive emotions may affect mainly corrugator supercilii or zygomaticus major activity, respectively. However, considering that the sample size of this study is relatively small (N = 20), although comparable with several previous studies (Cannon, Hayers & Tipper, 2009; de Morree & Marcora, 2011; Korb, Grandjean & Scherer, 2010), replication studies with larger sample sizes are needed, especially to confirm the tentative conclusion that regulation of negative and positive emotions are differentially reflected in corrugator and zygomaticus activity.

There are also some limitations of the present study. Firstly, it should be noted that although I carefully refrained from mentioning ‘emotion regulation’ or ‘facial expression’ in the instructions, participants might have still inferred the purpose of the study. Thus, they may have responded in a way that conforms to the hypotheses of this study. However, such demand characteristics are a general problem in studies on emotion regulation. The following studies that combine EMG with ‘less controllable’ measure (i.e., EEG) may offer further evidence. Secondly, to keep the task brief (i.e., within one hour), I did not include emotional contradictory conditions (i.e., a negative-positive condition and a positive-negative condition). Therefore, it remains to be clarified by future studies how neutral narratives differ from contradictory narratives in reducing responses to emotional stimuli.

In conclusion, this study provides support to the assumption that preceding appraisal frames can alter both emotional experience and facial expression. It extends previous work by revealing the efficacy of appraisal frames in modulating multiple systems of positive as well as negative emotional responses. In addition, this study shows that appraisal frames affect valence-specific activity patterns of corrugator supercilii and zygomaticus major muscles, both of which are important signs of emotions in social interaction.

3. Experiment 2: Prospective emotion regulation in smokers as reflected in self-reports, facial electromyographic and electroencephalogram activity

3.1 Introduction

The results described in the Experiment 1 demonstrated that appraisal frames preceding emotional stimuli could efficiently alter both positive and negative emotions as indexed by self-reported ratings and facial EMG activity (Wu et al., 2012). Previous studies by Hajcak and his colleagues found that appraisal frames preceding negative pictures could also manipulate brain activity as indexed by the late positive potential (LPP), an event-related potential (ERP) component involved in emotional processing (Foti & Hajcak, 2008; Hajcak & Olvet, 2008; Dennis & Hajcak, 2009).

The present study builds on the previous work by examining the prospective emotion regulation via appraisal frames in smokers. Clinical and functional imaging studies have noted that smokers are characterized by a decreased use of cognitive appraisal strategies and by malfunction in PFC regions as compared to nonsmokers (Goldstein & Volkow, 2011; Zhang et al., 2010; Sutherland et al., 2012; Jacobson et al. 2007; Musso et al., 2007). Smoking deprivation further affected performances on a variety of cognitive tasks related to attention, memory and emotion. In particular, abstinence from smoking (e.g., overnight deprivation) has been found to induce more negative experience, less attention to nonsmoking related stimuli, and smaller emotional reactions to nonsmoking stimuli (Cinciripini et al., 2006; Dar et al., 2010; Gilbert et al. 2007, 2008; Heishman, Kleykamp & Singleton, 2010; Lam et al., 2012; Onur et al., 2011). Therefore, it might be assumed that smokers would show deficit in cognitive emotion regulation, and that overnight deprivation from smoking would worsen this deficit. However, no study to date has specifically investigated emotion regulation via appraisal frames in nicotine addicts, not to mention the effect of smoking deprivation on cognitive emotion regulation. Therefore, a major aim of this study was to investigate whether and how smokers or deprived smokers may differ from nonsmokers on cognitive emotion regulation via appraisal frames.

An additional aim of this study was to test whether the smokers' craving to smoke and their emotions could be simultaneously altered by emotion regulation via appraisal frames. Previous studies showed that smoking cravings are associated with emotional state. Specifically, negative emotions may enhance cravings to smoke, and thus increase smoking behaviors (Dar et al. 2010). Consistently, some imaging studies expanded the finding by demonstrating that the brain mechanisms underlying smoking craving and emotion are overlapping (Kober et al., 2010). However, some other studies found that brain regions responsible for emotion and craving are separable and changes in emotions may not be bound to changes in craving (Born et al., 2011). Therefore, to clarify the correlation of emotion and smoking craving, it is necessary for future studies to investigate whether manipulation of emotional states may lead to corresponding changes in smoking cravings.

To address these above issues, the present study recruited smokers who regularly smoke more than 10 cigarettes per day during at least the last 12 months, and compared their emotion regulation ability with a group of nonsmokers who had smoked 2 or fewer cigarettes in their lifetime. Half of the smokers were allowed to smoke as usual and the other half were required to refrain from smoking 12 hours before they came to the experiment, thus forming a deprived smoking group and a nondeprived smoking group. The reports of emotional experience, cravings to smoke and psychophysiological responses during emotion regulation were examined using measures of self-rating scales, facial electromyography (EMG) activity, and electroencephalogram (EEG) activity.

I predicted that smokers have deficits in cognitive emotion regulation: smokers would respond to appraisal frames with smaller changes in subjective emotional experience, EMG and EEG activities as compared to nonsmokers, and this impairment would be more pronounced in deprived smokers as compared to nondeprived smokers. In particular, it was hypothesized that as compared to nondeprived smokers (1) the difference between emotional responses (i.e., self-ratings, amplitude of facial EMG activity over corrugator supercilii, and LPP activity) under negative-negative condition and emotional responses under neutral-negative conditions would be larger among nonsmokers and smaller among deprived smokers; (2) similarly, the difference between emotional responses (i.e., self-ratings, amplitude of facial EMG activity over zygomaticus major, and LPP activity) under positive-positive condition and emotional responses under neutral-positive conditions would be larger among nonsmokers and smaller among deprived smokers.

3.2 Method

3.2.1 Participants

In total, 35 nonsmokers (18 females) and 70 smokers (35 females) were recruited through online advertisements and posters. Participants were screened over phone or email to determine that they were either smokers or nonsmokers. Participant’s mean age was 24.74 years old (range 18-40). They had a high school diploma or equivalent, were not taking any prescription drugs and were fluent German speakers. Smokers were defined as persons who smoked an average of at least 10 cigarettes per day during at least the last 12 months, while nonsmokers (NS) were persons who had smoked fewer than 2 cigarettes in their lifetime. Smokers were randomly assigned to one of two groups: nondeprived smoking group and deprived smoking group. Individuals in the nondeprived smoking group (NDS) were asked to smoke as normal and to consume one cigarette immediately before they came to the laboratory. Individuals in the deprived smoking group (DS) were required to abstain from smoking over-night for about 12 hours prior to their appointments.

Further exclusion criteria included: 1) having personal history of drug addiction excluding nicotine dependence; 2) having current psychiatric or neurological disorders; 3) currently taking any smoking cessation medications and/or attending smoking cessation programs. According to these criteria, a total of 33 nonsmokers (16 females), 27 nondeprived smokers (15 females) and 28 deprived smokers (15 females) were confirmed to participate in the experiment. Most participants were students from the University of Würzburg and received either money (6 euro/h) or course credit. Deprived smokers were compensated with an extra 10 euro for their efforts to abstain from smoking. The demographic characteristics of the participants are provided in Table 1.

3.2.2 Materials

The picture stimuli and auditory narratives were the same as those in Experiment 1. In total, 25 neutral scenes, 50 positive scenes and 50 negative scenes were selected from the International Affective Picture System (IAPS; Lang et al., 2005). Auditory narratives were recorded in advance including 125 neutral narratives, 50 negative narratives for the negative pictures and 50 positive narratives for the positive pictures. The auditory narratives were presented binaurally via speakers with a sound intensity of 68dB.

Self-Assessment Manikins (SAM; Lang, 1980; Bradley and Lang, 1994) were used to measure stimulus evoked valence and arousal. To measure stimulus-evoked cravings to smoke, a similar instrument was developed with five bar graphs instead of five graphic figures to represent 9-level ratings for craving to smoke (1 = low craving, 9 = high craving) (see Figure 4).

A portable Smokerlyzer® carbon monoxide (CO) monitor (Bedfont Scientific Ltd, Kent, U.K.) was used to verify participants' smoking status. Carbon monoxide (CO) is a toxic gas by-product of incomplete combustion of carbon-containing fuels (Mayr et al., 2005). Smoking has been referred to as a major source of inhaled CO. The CO breath levels are given in parts per million (ppm) by the device: nondeprived smokers ≥10 ppm carbon monoxide, and nonsmokers ≤5 ppm (BreathCo, Vitalograph, Lenexa, KS); overnight deprived smokers ≤13 ppm (Stippekohl et al., 2010; Mucha, Geier & Pauli, 1999). The device was calibrated according to the manufacturer's instructions prior to use, and then biannually throughout the study.

3.2.3 Procedure and Apparatus

All experimental sessions were conducted in the afternoon or evening in order to minimize differences in duration of smoking deprivation in the DS group. After reading the instructions for the experiment and signing the informed consent, participants completed a simple CO test and filled out the questionnaire. The questionnaire set included a general demographics questionnaire, the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker & Fagerstrom, 1991), the German version of the State Trait Anxiety Inventory questionnaire (STAI; Laux, Glanzmann, Schaffner, and Spielberger, 1981), and the German version of the Beck Depression Inventory questionnaire (BDI; Hautzinger et al., 1995)[5]. Participants were then seated in a comfortable chair in a sound attenuated and dimly lit room. Electroencephalograph (EEG) sensors and facial electromyography (EMG) sensors were attached. To decrease demand characteristics, participants were informed that their skin conductance was to be measured as they viewed some pictures. Statements relevant to “emotion regulation” and “facial expression” were not made.

Three initial practice trials were given to explain the procedure. Next, the experimental session started, consisting of 125 trials with 25 trials for each of the five experimental conditions: neutral pictures, negative pictures, or positive pictures preceded by neutral appraisal frames; and negative, or positive pictures preceded by negative or positive appraisal frames respectively (i.e., neutral-neutral, positive-positive, neutral-positive, neutral-negative, and negative-negative). The trials were pseudorandomized so that no more than three trials from the same condition were presented successively.

Each trial began with a white fixation cross presented on a black screen for a period ranging randomly from 4 to 5 sec. The fixation cross turned to blue one second before the onset of the auditory narratives which could last from 2 to 4 sec. Similar to Experiment 1, half of the positive pictures were preceded by positive narratives (positive-positive condition) and half of the negative pictures were preceded by negative narratives (negative-negative condition). The other halves of the emotional pictures were preceded by neutral narratives (neutral-positive condition and neutral-negative condition). All of the neutral pictures were preceded by neutral narratives (neutral-neutral condition). Following each narrative, there was a 1 sec delay and then

[5] See appendix 2

the corresponding picture was presented for 4 sec. At the offset of each picture, the SAM scales appeared on the screen and participants rated how they felt during picture presentation. There were breaks after every 25 trials. The whole experimental session lasted about 40 min.

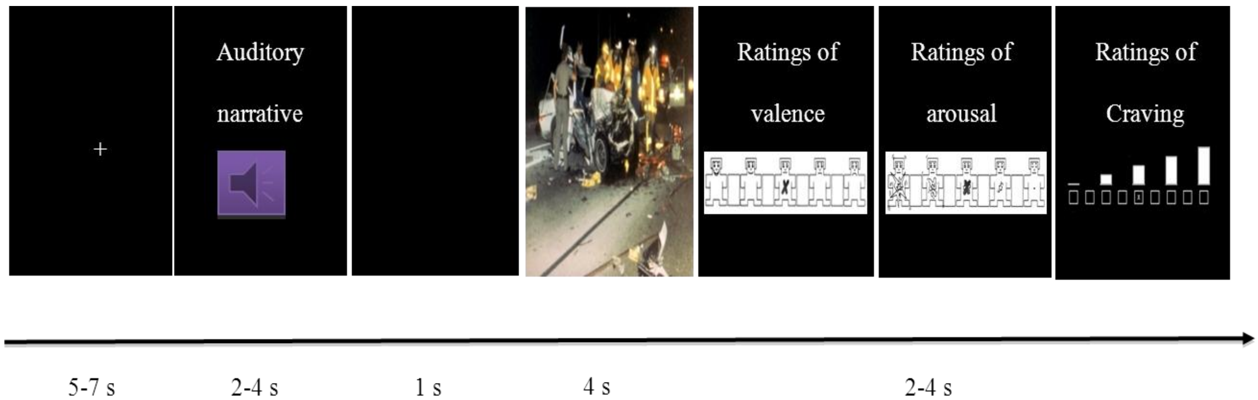


Figure 4. An example of one trial of Experiment 2.

At the end of the test, participants completed the German version of the Emotion Regulation questionnaire (ERQ, Gross & John, 2003)[6]. And then, they were debriefed and thanked.

3.2.4 Psychophysiological data recording

The continuous EMG and EEG were recorded at 1000 Hz through a V-Amp 16 amplifier (Brain Products Inc., Gilching, Germany). Facial electromyographic (EMG) activity was measured over the corrugator and zygomaticus muscle regions. Before electrode placement, sites were swabbed with an alcohol prep pad and then gently abraded using a skin preparation paste. Then pairs of two 7-mm Ag/AgCl electrodes were placed over the left eye (corrugator) and left cheek (zygomaticus) according to guidelines provided by Fridlund and Cacioppo (1986). Based

[6] See appendix 2

on previous research indicating that the LPP is typically maximal at posterior and parietal sites, the EEG was recorded using an EasyCap (EasyCap, Hersching, Germany) from 10 positions including FCz, Cz, CPz, Pz, C1, C2, CP1, CP2 (Foti & Hajcak, 2008; Hajcak & Olvet, 2008; Keil et al., 2002; Schupp et al., 2000), and the left and right mastoids. Vertical EOG was recorded from electrodes placed 1 cm above and below the right eye, and horizontal EOG was recorded with two electrodes 1 cm from the outer epicanthus of each eye. FCz was used as ground. Reference was placed at Cz during data recording and replaced by the mean of mastoids during off-line data analysis. Impedance was kept below 10 kΩ at all sites (see figure 5).

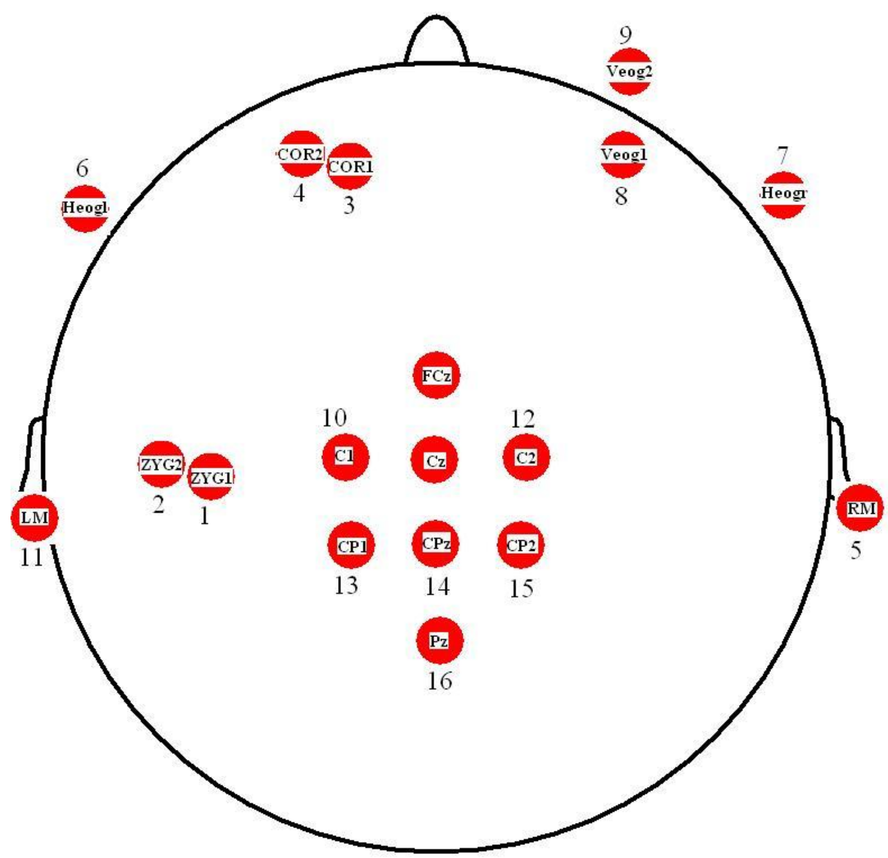


Figure 5. Top view of subject's head and positions of electrodes for the recording brain waves (International 10–20 Electrode Placement System).

3.2.5 Data Reduction

Off-line analyses of the EMG and EEG activity were conducted with Brain Vision Analyzer Software (Version 2.0, Brain Products Inc., Gilching, Germany)[7].

The EMG data was re-referenced to obtain bipolar recordings. The raw signal was filtered with a band-pass filter from 30 Hz to 500 Hz and a 50 Hz notch filter. Subsequently, the data were rectified and smoothed using a 125 ms moving average filter. Trials with an EMG activity above 8 μV or below -8 μV during the baseline (mean EMG activity over 1000 ms preceding picture onset) and above 30 μV or below -30 μV during picture presentation were excluded. Before statistical analysis, EMG activity was measured as the difference between the mean activity during the 4 sec picture period and the 1 sec baseline. The corrugator activity and zygomaticus activity were scored as the average activity in the time window 300–4000 ms over the corrugator supercilii and zygomaticus major muscle respectively.

EEG data was band-pass filtered between 0.01 and 20 Hz and then segmented (−100 to 4000 ms with respect to stimulus onset). Subsequently, the data was corrected for ocular artifacts using the method developed by Gratton et al. (1983). An automated procedure was used to reject remaining artifacts according to the following criteria: a voltage step of more than 50.00 μV between sample points, a voltage difference of more than 300.00 μV within a trial, and a

[7] Participants who were tested after 7pm, particularly the deprived smokers, frequently reported tiredness, sleepiness and restless during the experiment. Moreover, explorative data analyses showed that their EEG and EMG data were quite noisy as compared to those who were tested before 7pm. Therefore, I excluded participants who were tested after 7pm and reported results of 60 participants who were tested between the hours of 12:30 pm and 7:00 pm.

maximum voltage difference of less than 0.50 μV within 100 ms intervals. EEG recordings were then re-referenced to the numeric mean of mastoids, and baseline corrected (-100 ms).

Self-reports, EMG and ERPs were constructed by averaging trials per each condition per participant[8]. Based on previous research indicating that the LPP is typically maximal at posterior and parietal sites (Foti & Hajcak, 2008; Hajcak & Olvet, 2008; Hajcak, 2009; Keil et al., 2002; Schupp et al., 2000), the LPP was scored as the average activity in the time window 300–4000 ms at CPz, CP1, and CP2.

3.2.6 Statistical analyses

First of all, multivariate analyses (MVA) were conducted to test for differences among nonsmokers, nondeprived smokers and deprived smokers in the questionnaire scores.

A manipulation check was then conducted to test whether participants (nonsmokers, deprived smokers, and nondeprived smokers) responded differently to neutral, negative and positive pictures. I selected the baseline condition (i.e., neutral-neutral) and two other emotion congruent conditions (i.e., positive-positive, and negative-negative) during which pictures were matched with emotion consistent narratives. Then repeated ANOVA analyses separated for each dependent variable (i.e., self-reports and psychophysiological responses) were conducted with condition (neutral-neutral, positive-positive, and negative-negative) as a within-subjects factor and group (NS, NDS, DS) as a between-subjects factor. Paired *t*-tests were performed to further examine main effects.

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[8] On average 13.25% of the trials were rejected due to artifacts which left an average of 21.69 trials per subject and per condition.

I examined the effects of appraisal frames on subjective experience and psychophysiological responses among smokers and nonsmokers. Difference scores were calculated by subtracting data scores of the baseline condition (i.e., neutral narratives preceding neutral pictures) from each condition. For corrugator, zygomaticus and LPP activity, however, I first performed a priori tests based on the following specific hypotheses. For corrugator activity I expected enhanced activity in the negative-negative compared to the neutral-negative condition; for zygomaticus activity I expected enhanced activity in the positive-positive compared to the neutral-positive condition; for LPP activity, I expected enhanced activity in the negative-negative compared to the neutral-negative condition, as well as enhanced activity in the positive-positive compared to the neutral-positive condition. I did not expect effects of negative or positive emotions and their regulation on zygomaticus or corrugator activity, respectively, and although this null hypothesis cannot be tested, I exploratively performed *t*-tests comparing these conditions. The difference scores of the EMG and the EEG activity were then submitted to a repeated analyses of variance (ANOVA) with picture valence (positive, negative) and appraisal frame (neutral, emotion consistent) as within-subject factors, and group (NS, NDS, DS) as a between-subjects factor. Dependent variables included self-reported valence, self-reported arousal, self-reported craving, corrugator activity, zygomaticus activity, and LPP. Paired *t*-tests were conducted to further examine main effects.

Moreover, difference scores were calculated by subtracting data scores of the emotion-incongruent condition (i.e., neutral narratives preceding positive or negative pictures) from the emotion-congruent condition (i.e., positive or negative narratives preceding positive or negative pictures, respectively). These difference scores were then submitted to Pearson correlation analysis to explore whether self-reported craving to smoke and emotions change simultaneously, whether the dependent variables (i.e., self-ratings, EMG and EEG) are altered consistently by appraisal frames, and whether participants' performance on emotion regulation is correlated with craving regulation.

For all analyses the alpha-level was set at .05. The Greenhouse-Geisser correction was applied when the assumption of sphericity was violated. The uncorrected degrees of freedom and effect sizes (partial eta-squared, η^2_p) are reported.

3.3 Results

3.3.1 The demographic characteristics of participants

The demographic characteristics of the participants are provided in Table 1. Multivariate analyses (MVA) indicated that comparing to nondeprived smokers, deprived smokers had lower CO level (F (1, 36) = 17.38, $p < .01$, $\eta^2_p = .33$), and nonsmokers had lower BDI scores (F (1, 39) = 4.47, $p < .05$, $\eta^2_p = .68$). No other comparisons among the three groups reached statistical significance (ps > .11).

Table 1. Experiment 2: Means (and standard deviations) of the demographic characteristics of participants.

Participant characteristics	Nonsmoker (*n* = 22)	Nondeprived smoker (n = 19)	Deprived smoker (n = 19)
Female	11	11	9

Age (ys)[a]	25.05 (5.68)	23.74 (2.58)	24.53 (2.58)
Carbon monoxide (CO)[b]	1,45 (0,91)	15,58 (9,70)	4,58 (6,18)
Cigarettes per day[a]	N/A	14,37 (6,47)	12,9 (4,73)
Age to start smoking[a]	N/A	16,53 (3,22)	16,58 (3,60)
History of smoking (ys)[a]	N/A	7,21 (2,94)	7,95 (3,83)
Fagerström Test for Nicotine Dependence (FTND)[a]	N/A	4 (2,08)	3,05 (1,62)
Emotion regulation questionnaire (ERQ, reappraisal)[a]	27,18 (6,59)	29,42 (11,43)	26,21 (6,49)
Emotion regulation questionnaire (ERQ, suppression)[a]	13,09 (4,50)	13,16 (4,70)	15,68 (6,10)
State-Trait Anxiety Inventory (STAI)[a]	36,68 (7,93)	39,32 (8,76)	39,21 (8,97)
Beck Depression Inventory (BDI)[c]	4,77 (4,45)	7,87 (4,93)	7,84 (7,34)

3.3.2 Manipulation check

The ANOVA revealed a significant main effect of condition on all dependent variables[9]: self-reported valence (F (2, 114) = 362.10, $p < .01$, $\eta^2_p = .86$); self-reported arousal (F (2, 114) = 119.31, $p < .01$, $\eta^2_p = .68$); self-reported craving (F (2, 114) = 4.10, $p < .05$, $\eta^2_p = .07$); corrugator activity (F (2, 114) = 19.67, $p < .01$, $\eta^2_p = .26$); zygomaticus activity, (F (2, 114) = 9.40, $p < .01$, $\eta^2_p = .14$); and LPP activity (F (2, 114) = 5.31, $p < .01$, $\eta^2_p = .09$).

Follow-up *t*-tests indicate that participants on the one hand responded to the negative-negative condition with more negative self-ratings (t (59) = -19.11, $p < .01$), higher level of self-reported arousal (t (59) = 20.27, $p < .01$), larger craving to smoke (t (59) = 1.79, $p < .05$); larger LPP activity (t (59) = 3.00, $p < .01$), larger corrugator supercilli activity (t (59) = 3.28, $p < .01$), and smaller zygomaticus activity (t (59) = -2.40, $p = .01$) compared to the neutral-neutral condition. On the other hand, participants responded to positive-positive condition with more positive self-ratings (t (23) = 15.53, $p < .01$), higher level of self-reported arousal (t (59) = 6.64, $p < .01$), larger craving to smoke (t (59) = 2.26, $p < .05$), larger LPP activity (t (59) = 1.76, $p < .05$), smaller corrugator supercilli activity (t (59) = -5.42, $p < .01$), and larger zygomaticus activity (t (59) = 2.56, $p < .01$) again compared to the neutral-neutral condition.

There was also a significant main effect of group on self-reported craving (F (2, 57) = 44.91, $p < .01$, $\eta^2_p = .61$). Post-hoc tests indicated that compared to the NS group, the NDS group

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[9] The means and standard error of self-ratings, EMG activities and LPP activities to each of the three emotion-congruent conditions (i.e., negative-negative, positive-positive, and neutral-neutral) by the NS group, NDS group, and the DS group are depicted in appendix 3.

and the DS group reported significantly larger craving to smoke (NDS: $p < .01$; DS: $p < .01$), while the difference between the NDS group and the DS group did not reach statistical significance ($p = .58$). None of the other main effects and interactive effects reached statistical significance.

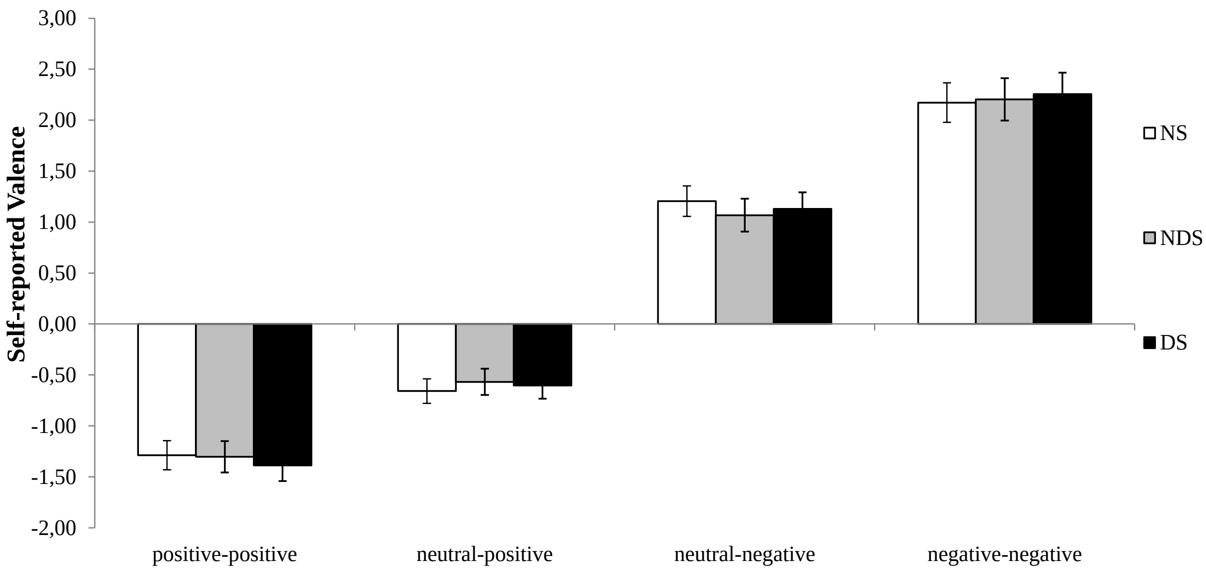
3.3.3 Effect of appraisal frame on self-reported valence, arousal and craving in smokers and nonsmokers

Mean changes in self-reports depending on emotion conditions are depicted in Figure 6.

Self-reported valence. The ANOVA revealed main effects of picture valence (F (1, 57) = 351.77, $p < .01$, $\eta^2_p = .86$) and appraisal frame (F (1, 57) = 21.87, $p < .01$, $\eta^2_p = .28$). However, the main effect of group did not reach statistical significance (F (2, 57) < 0.001). There was a significant interaction effect of picture valence by appraisal frame (F (1, 57) = 200.38, $p < .01$, $\eta^2_p = .78$). Thus, the negative-negative condition was rated as more negative than the neutral-negative condition (t (59) = 15.14, $p < .01$). And the positive-positive condition was rated as more positive than the neutral-positive condition (t (59) = -9.39, $p < .01$). None of the other interaction effects reached statistical significance (ps > .53).

Self-reported arousal. The ANOVA revealed main effects of picture valence (F (1, 57) = 89.89, $p < .01$, $\eta^2_p = .61$) and appraisal frame (F (1, 57) = 20.01, $p < .01$, $\eta^2_p = .26$). The main effect of group was not significant (F (2, 57) = 0.04, $p = .96$, $\eta^2_p = .00$). There was a significant interaction effect of picture valence by appraisal frame (F (1, 57) = 33.55, $p < .01$, $\eta^2_p = .37$). Follow-up t-tests revealed that the negative-negative condition was rated as more arousing than the neutral-negative condition (t (59) = 7.89, $p < .01$).). However, there was no reliable difference between positive-positive and neutral-positive conditions (t (59) = 1.23, p = .22). None of the other interaction effects reached statistical significance (ps > .24).

Self-reported craving. The ANOVA revealed main effects of picture valence (F (1, 57) = 7.37, p = .01, η^2_p = .11). Negative pictures evoked significantly larger craving to smoke that positive pictures. Neither the main effect of group (F (2, 57) = 0.46, p = .63, η^2_p = .02) nor the main effect of appraisal frame (F (1, 57) = 0.00, p = .96, η^2_p = .00) reached statistical significance. The interaction effect of picture valence by group failed to reach the significance level (F (2, 57) = 2.65, p = .08, η^2_p = .09). For explorative purposes, I followed-up this marginally significant interaction considering the three groups separately. Negative pictures evoked significantly larger craving to smoke than positive pictures only in the NDS group (F (1, 18) = 9.47, p < .01, η^2_p = .35) but neither in the DS group (F (1, 18) = 0.87, p = .36, η^2_p = .05) nor in the NS group (F (1, 21) = 0.64, p = .43, η^2_p = .03). None of the other interaction effects reached statistical significance (ps > .08).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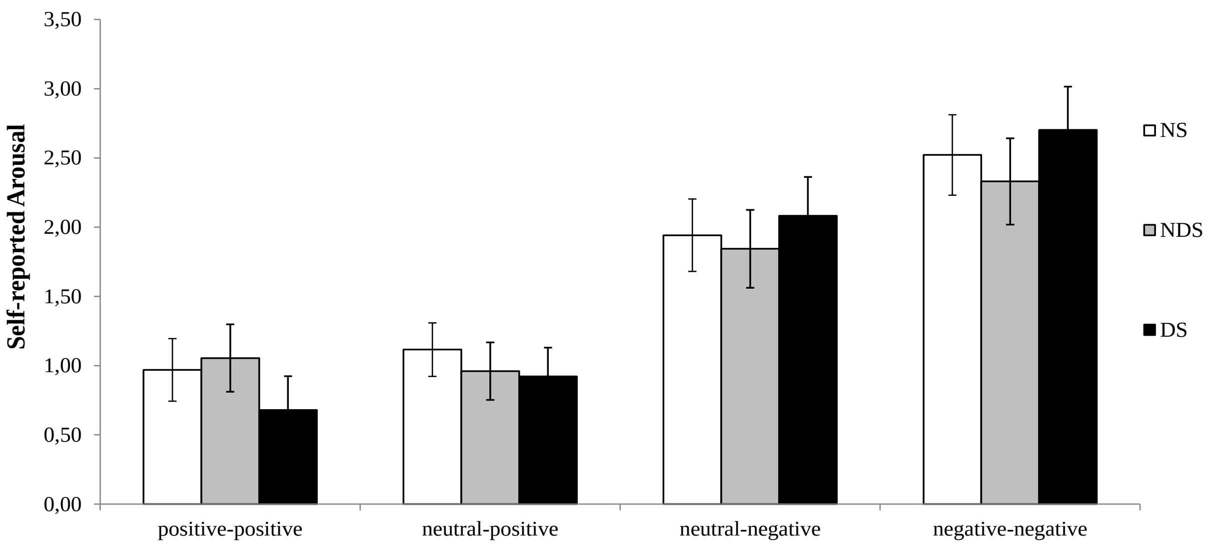
Self-reported Valence
positive-positive
neutral-positive
neutral-negative
negative-negative
NS
NDS
DS


3,50
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Self-reported Arousal
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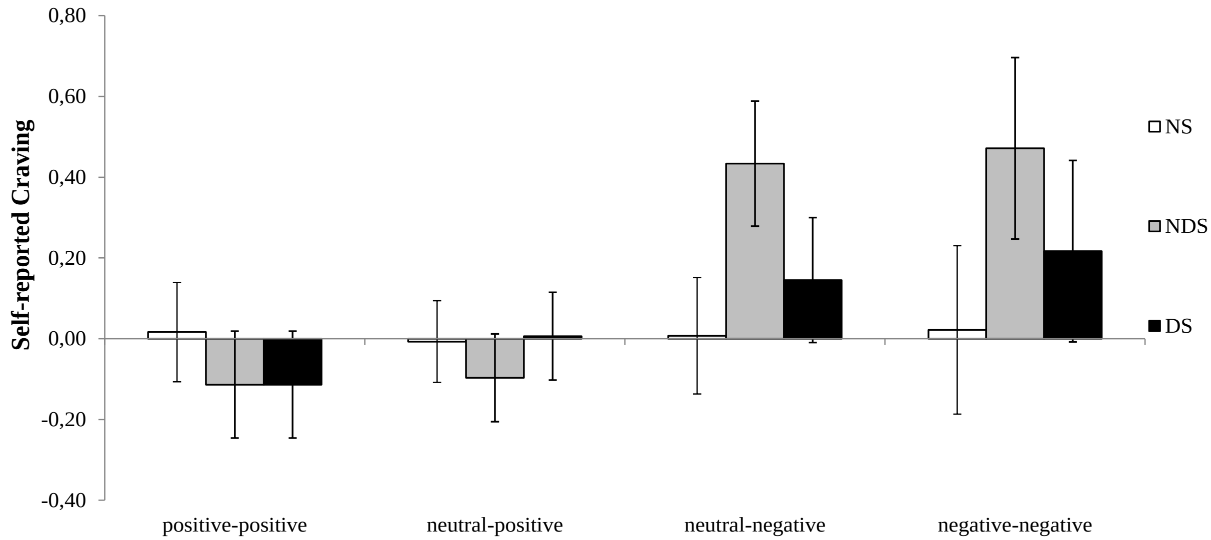


Figure 6. Effect of appraisal frames on ratings of valence, arousal and craving across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS). Depicted are changes in self-reported valence (top), self-reported arousal (middle) and self-reported craving (bottom) as a function of appraisal frame among the three groups. Each bar represents the difference score between neutral condition and one of the four conditions (positive-positive, neutral-positive, neutral-negative, and negative-negative). Error bars represent standard error of the mean (SEM).

3.3.4 Effect of appraisal frame on psychophysiological responses in smokers and nonsmokers

Mean changes in EMG activity and LPP activity are depicted in Figure 7 and Figure 8 respectively.

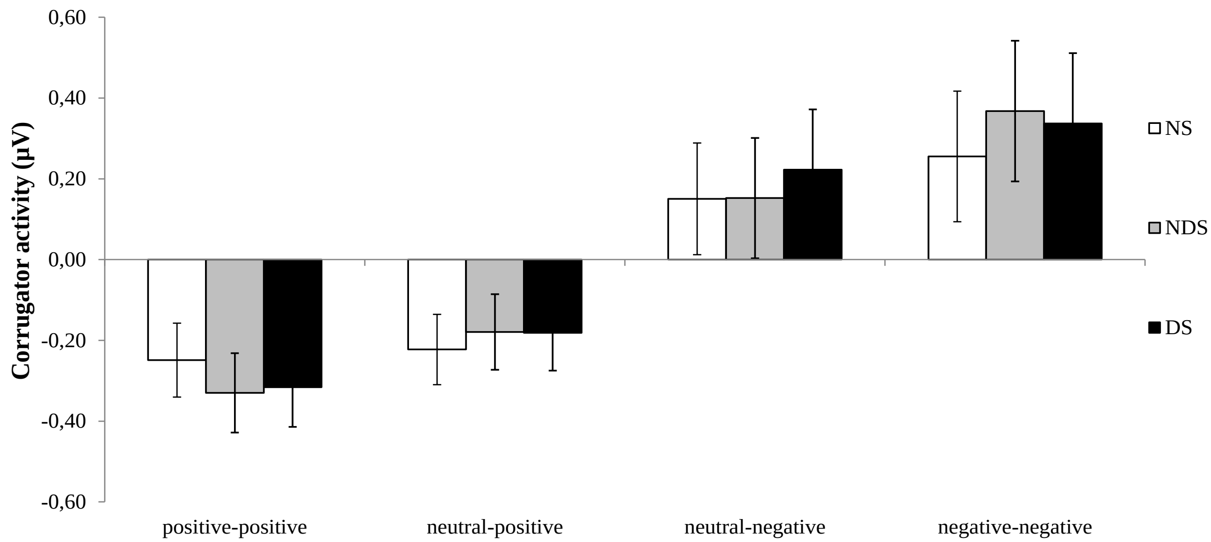
Corrugator activity. The a priori *t*-tests showed that corrugator activity was higher in the negative-negative condition compared to the neutral-negative condition (t (59) = 2.39, p < .05). The exploratory comparison of the corrugator activity between the positive-positive and neutral-positive conditions also reached statistical significance (t (59) = -2.01, p = .05), indicating decreased corrugator activity in the positive-positive condition compared to the neutral-positive condition.

The ANOVA revealed a significant main effect of picture valence (F (1, 57) = 20.64, p < .01, η^2_p = .27). Neither the main effect of appraisal frame (F (1, 57) = 0.32, p = .57, η^2_p = .01) nor the main effect of group (F (1, 57) = 0.05, p = .95, η^2_p < .001) reached statistical significance. The interaction effect of picture valence by appraisal frame was significant (F (1, 57) = 8.76, p < .01, η^2_p = .13). None of the other interaction effects reached statistical significant (*p*s > .52).

Zygomaticus activity. The a priori *t*-tests showed that zygomaticus activity was higher in the positive-positive than the neutral-positive condition (t (59) = 2.03, p < .05). The exploratory comparison of the zygomaticus activity between the negative-negative conditions compared to the neutral-negative conditions failed to reach statistical significance (t (59) = -1.27, p = .11).

The ANOVA revealed a significant main effect of picture valence (F (1, 57) = 10.88, p < .01, η^2_p = .16), but neither the main effect of appraisal frame (F (1, 57) = 1.23, p = .27, η^2_p = .02) nor the main effect of group (F (1, 57) = 0.09, p = .91, η^2_p = .00) reached statistical significance. None of the interaction effects was significant (*ps* > .20) except for the interaction effect of picture valence by appraisal frame (F (1, 57) = 5.78, p < .05, η^2_p = .09).

LPP activity. The a priori paired *t*-tests revealed that LPP activity was greater in the negative-negative than the neutral-negative condition (t (59) = 2.07, p < .05). The exploratory *t*-test comparing the positive-positive condition to the neutral-positive condition was not significant (t (59) = 0.58, p = .28). The ANOVA revealed that none of the main effects and interaction effects reached statistical significance (*p*s > .13) [10].



[10] A repeated ANOVA analyses with condition (neutral-negative and negative-negative) as a within-subjects factor and group (NS, NDS, DS) as a between-subjects factor was conducted to further investigate how the three groups differ on emotion regulation via the appraisal frames. The results revealed a significant main effect of condition (F (1, 57) = 4.41, p < .05, η^2_p = .07). Neither the main effect of group (F (2, 57) = 0.65, p = .26, η^2_p = .02), nor the interactive effect of condition by group was significant (F (2, 57) = 0.82, p = .45, η^2_p = .03). Paired t-tests showed that LPP activity was significantly greater under the negative-negative condition than the neutral-negative condition among the NDS group (t (18) = 1.80, p = .05), but not among the NS group (t (21) = 0.83, p = .21) and the DS group (t (18) = 0.83, p = .21).

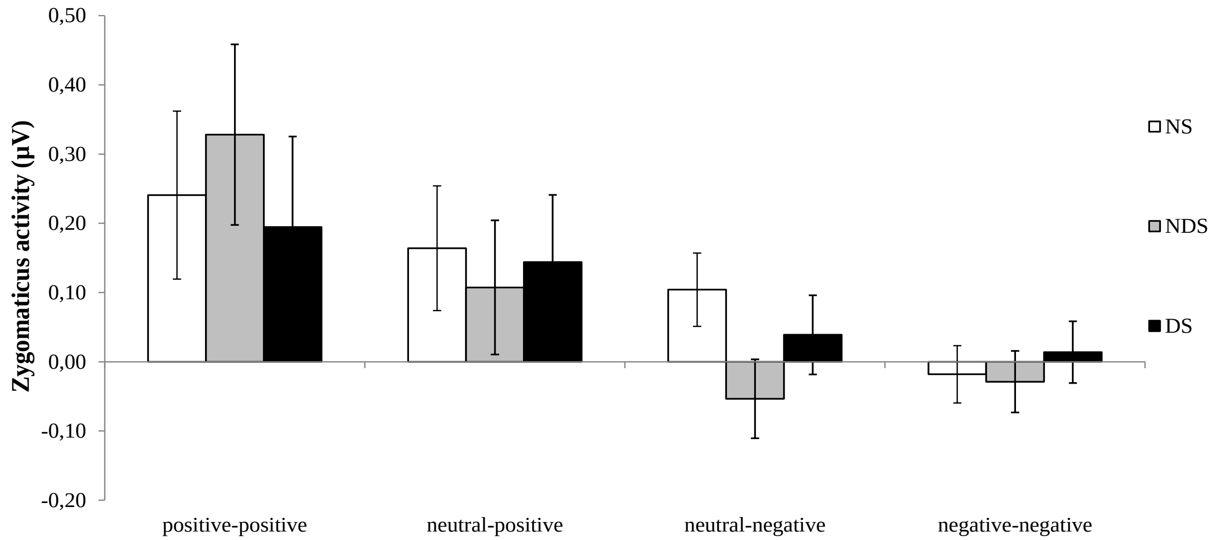
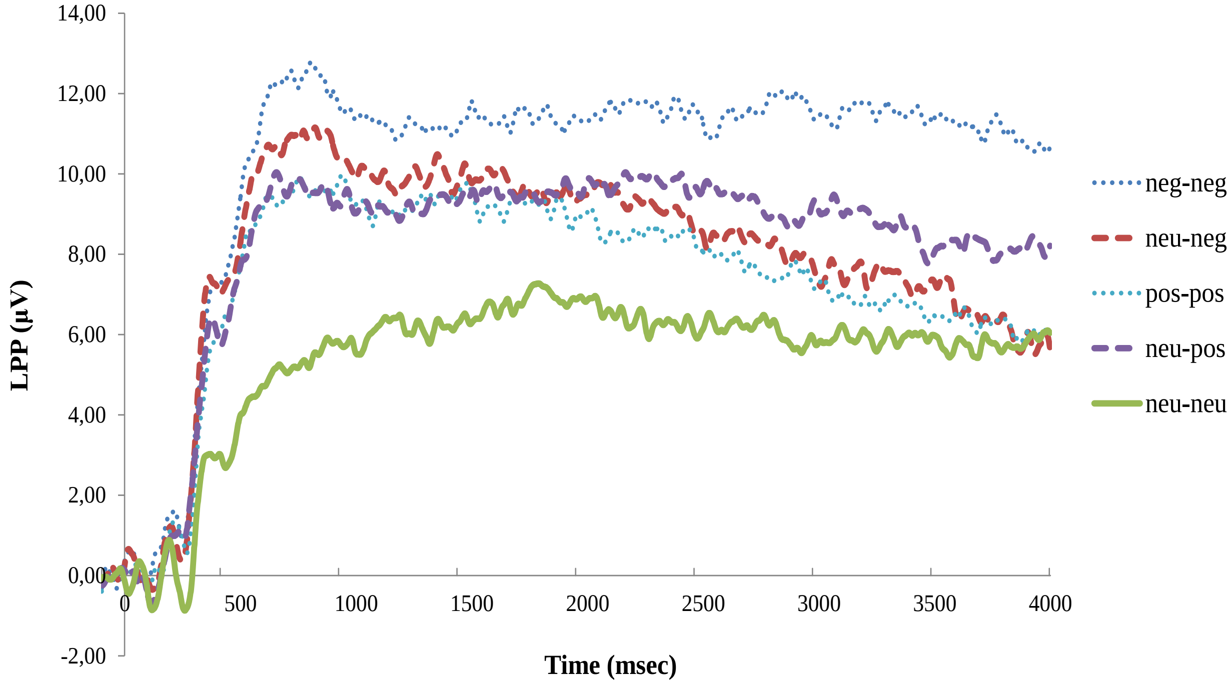


Figure 7. Effect of appraisal frames on facial EMG activity across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS). Depicted are changes in corrugator activity (top) and zygomaticus activity (bottom) as a function of appraisal frame of the three groups. Each bar represents the difference score between one of the four conditions (positive-positive, neutral-positive, neutral-negative, and negative-negative) and the neutral condition. Error bars represent standard error of the mean (SEM).



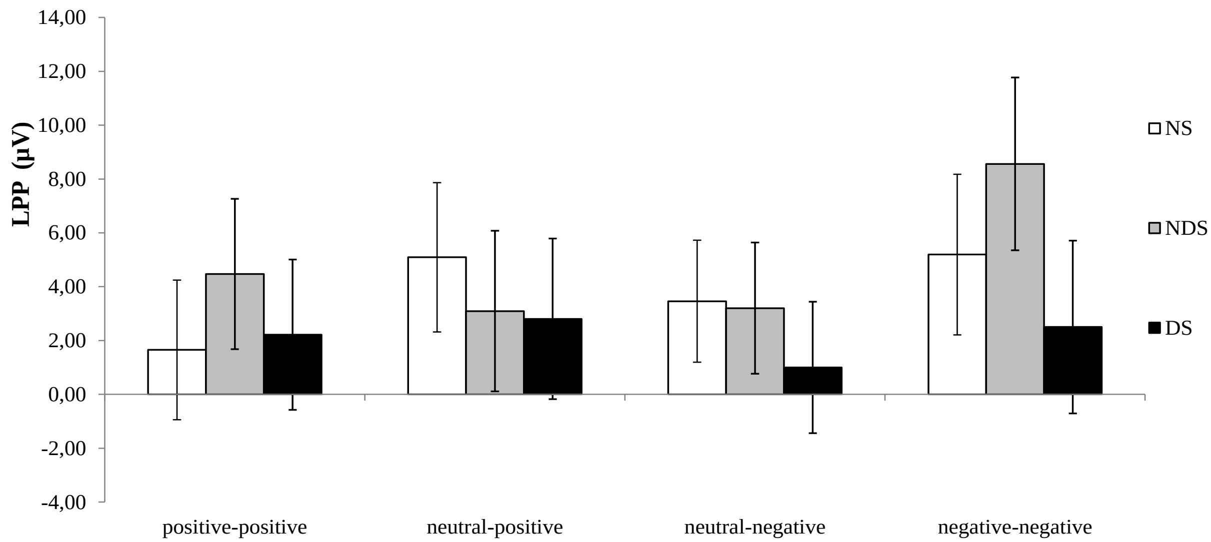


Figure 8. Dynamic changes in LPP activity (top) and the effect of appraisal frames on LPP activity across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS) (bottom). A. Depicted are grand averaged ERPs during the time window from 0 to 4 s per condition at central–parietal recording sites elicited by each condition: Neutral pictures were

always associated with neutral narratives (green solid line); negative pictures were preceded by either negative narratives (dark blue dotted line) or neutral narratives (red dashed line); positive pictures were preceded by either positive narratives (light blue dotted line) or neutral narratives (purple dashed line). B. Depicted are changes in LPP activity as a function of appraisal frame across the three groups of participants. Each bar represents the difference score between one of the four conditions (positive-positive, neutral-positive, neutral-negative, and negative-negative) and the neutral-neutral condition. Error bars represent standard error of the mean (SEM).

3.3.5 Correlations of multiple measurements

There was a significantly positive correlation between self-reported valence and self-reported arousal irrespective of the valence of emotional stimuli. The larger the changes in self-reported valence as a result of appraisal frames, the greater the changes in self-reported arousal were observed (N = 60; positive stimuli: $r = .25$, $p < .01$; negative stimuli, $r = .50$, $p = .05$). The changes in self-reported craving were positively correlated with the modulation of self-reported arousal with respect to the negative stimuli (N = 60; $r = .33$, $p = .01$) but not with respect to the positive stimuli (N = 60; $r = .16$, $p = .22$). The changes in corrugator activity were negatively correlated with FTND scores with respect to the positive stimuli (N = 60; $r = -.30$, $p < .05$). The changes in zygomaticus activity were positively correlated with BDI scores (N = 60; $r = .28$, $p < .05$) and STAI scores (N = 60; $r = .27$, $p < .05$) with respect to the negative stimuli.

3.4 Discussion

This study examined the following issues: 1) whether nonsmokers, nondeprived smokers and deprived smokers differ in their emotional responses to emotional pictures depicting natural rewards; 2) whether the three groups of participants differ in their cognitive ability to regulate emotion via appraisal frames; 3) whether appraisal frames alter both emotional responses and cravings to smoke; 4) whether self-reported emotions are consistent with psychophysiological responses as indexed by facial EMG activity and LPP activity; and 5) whether smokers' performance on emotion regulation task is predicted by smoking dependence as measured by questionnaires. To address these issues, the present study investigated participants' responses under emotion-congruent conditions (i.e., neutral-neutral, negative-negative and positive-positive) that is when there was no emotional confliction between appraisal frames and emotional pictures, and two distinct emotion-incongruent conditions (i.e., neutral-negative and neutral-positive) during which participants were primed by neutral appraisal frames to down regulate the emotions elicited by the picture.

The manipulation check of emotion-congruent conditions showed that compared to neutral pictures, negative pictures evoked more unpleasant emotions (i.e., more negative and higher arousal ratings, greater corrugator activity, and enhanced LPP activity), and positive pictures induced more pleasant emotions (i.e., more positive and higher arousal ratings, greater zygomaticus activity, and larger LPP activity). There was no group difference on emotional responses as both nondeprived smokers and deprived smokers showed comparable responses to emotional pictures as nonsmokers. The results suggested that processing of emotional stimuli is not affected by nicotine addiction.

Most importantly, the present study did not find group difference in cognitive emotion regulation. Namely, smokers and nonsmokers showed equal emotional regulation on the explicit level (subjective ratings) and the implicit level (the psychophysiological responses). Specifically, under emotion-incongruent conditions (i.e., neutral-positive, and neutral-negative), all participants responded to emotional pictures with less arousing and more neutral ratings together with reduced amplitude of EMG and EEG activity, as compared to corresponding emotion-congruent conditions (i.e., positive-positive, and negative-negative). These results suggested that both smokers and nonsmokers can take advantage of appraisal frames to regulate their emotions. Importantly, the abstinence from smoking did not influence participants' efficiency of this regulation strategy. Furthermore, correlation analyses showed that the level of nicotine dependence as measured by questionnaires (e.g., FTND) could not predict changes in emotional responses during the emotion regulation and this is in line with lack of difference reported above. Therefore, it is concluded that smokers are not impaired in ability to regulate emotion via appraisal frames.

These results did not support the hypothesis that nicotine addicts have a deficit in cognitive emotion regulation. Previous imaging studies have demonstrated that heavy smokers have abnormal brain activities in the PFC regions that are assumed to be responsible for cognitive emotion regulation (Goldstein & Volkow, 2011; Zhang et al., 2010; Sutherland et al., 2012; Damasio, 1996; Davidson, 2004, Ochsner and Gross, 2005; Jacobson et al., 2007; Musso et al., 2007). A possible explanation could be that the task used in this study was too easy to detect deficits in smokers. There was a floor effect which could indicate that cognitive efforts based on PFC regions were not necessarily involved. Thus, with the help of preceding appraisal frames, all participants could alter their interpretations of emotional stimuli and thus regulate emotions without much cognitive effort. Therefore, to draw more convincing conclusions, future studies should apply more difficult challenges of emotion regulation.

Regarding the aspect of craving regulation and its correlation with emotion regulation, some prior work assumed that any manipulation affecting craving should be bound to emotion regulation because of overlapping brain regions underlying craving and emotions (Koob & Moal, 2006). However, other findings reported separate brain regions specific for craving and emotions (Beridge et al., 2003). This is the first study to address whether emotional responses and cravings to smoke are simultaneously altered as a result of emotion regulation strategies. The results showed that nonsmokers reported no craving to smoke at all; nondeprived smokers indicated less craving to smoke under the condition when appraisal frames aimed to reduce negative emotions in general, whereas deprived smokers still indicated high cravings to smoke across all conditions. Therefore, these results suggest that smokers' emotional responses and their cravings to smoke were not simultaneously altered by appraisal frames, particularly when the craving to smoke was very high as noted in deprived smokers or very low as noted in nonsmokers. Future studies that compare brain mechanisms underlying regulation of craving with regulation of emotion will be of interest.

In conclusion, this study suggests that smokers do not differ from nonsmokers in their emotional responses and their ability to cognitively regulate emotions. With the help of preceding appraisal frames, all participants could simultaneously alter emotional experience and corresponding psychophysiological responses. This study further confirmed the results of Experiment 1 by revealing the efficacy of appraisal frames in modulating multiple systems of positive as well as negative emotional responses. In addition, it was determined that smoking dependence and abstinence from smoking influence neither emotional response to nonsmoking stimuli, nor emotion regulation via appraisal frames. These results should be confirmed by using more difficult appraisal tasks to compare cognitive ability to regulate emotions in smokers and nonsmokers.

4. Experiment 3: Retrospective emotion regulation in smokers as reflected in self-reports, facial electromyographic and electroencephalogram activity

4.1 Introduction

The results from Experiment 2 demonstrated that both smokers and nonsmokers can efficiently regulate emotions via appraisal frames. As discussed above, the results may reflect a floor effect since the emotion regulation with appraisal frames requires little cognitive effort. It is assumed that smokers, particularly the deprived smokers, would show a deficit in a more difficult task requiring cognitive effort in altering emotions.

Reappraisal is a retrospective form of cognitive emotion regulation. It refers to the way that individuals modulate the interpretation of an emotional stimulus after an initial interpretation has occurred (Gross & Thompson, 2007; Hajcak & Nieuwenhuis, 2006; Dan-Glauser & Gross, 2011; Moser et al., 2010; Ochsner & Gross, 2008; Piper & Curtin, 2006; Ray et al., 2010; Urry, 2009). In a number of previous studies, participants were asked to self-generate narratives following instructions (such as 'enhance' or 'decrease') to regulate their initial emotional response. This emotion regulation procedure is more explicit and more effortful than the emotion regulation process with appraisal frames (Foti & Hajcak, 2008; Gyurak et al., 2011). It has been noted that variations in the amount of effort invested in the emotion regulation task may lead to variations in the efficiency of emotion regulation (Ray et al., 2010).

Therefore, this study aimed to further investigate emotion regulation in smokers and nonsmokers using reappraisal strategy. Similar to Experiment 2, the present study recruited three groups of participants: nondeprived smokers, deprived smokers and nonsmokers. The reports of emotional experience, cravings to smoke and psychophysiological responses during emotion regulation were examined through multiple measures (i.e., self-rating scales, facial electromyography activity, and electroencephalogram activity).

Previous studies have shown that nicotine addiction is associated with malfunction in PFC regions and frequent use of maladaptive emotion regulation strategies (Szasz et al., 2012; Fucito et al., 2010; Baker et al., 2004; Magen & Gross & Thompson, 2007; Goldstein & Volkow, 2011; Zhang et al., 2010; Sutherland et al., 2012), and that abstinence from smoking undermined smokers' performances in a number of cognitive tasks (Gilbert et al. 2004 ; Lawrence et al., 2002; Rusted et al. 1998). Accordingly, it is hypothesized that smokers will show deficits in emotion regulation when they are required to self-generate reinterpretations of emotional stimuli. In particular, I expected the changes in both self-reported emotions and psychophysiological responses (i.e., facial EMG activity and LPP activity) as a result of reappraisal instructions (i.e., 'maintain' vs. 'decrease') would be smaller among smokers as compared to nonsmokers. And this impairment would be more pronounced in deprived smokers compared to nondeprived smokers.

4.2 Method

4.2.1 Participants

77 participants (25 nonsmokers, and 52 smokers), aged 18 or older, were recruited through Internet advertisements and posters. Participants were screened over phone or email to ensure that they were smokers or nonsmokers. All participants had a high school diploma or equivalent, were not taking any prescription drugs and were fluent German speakers. Extra exclusion criteria

included: 1) having personal history of drug addiction excluding nicotine dependence; 2) having current psychiatric or neurological disorders; 3) currently taking any smoking cessation medications and/or participating in smoking cessation programs. According to these criteria, 25 nonsmokers (12 females), 50 smokers (25 females) were confirmed to participant in the experiment.

Similar to Experiment 2, smokers were defined as persons who smoked an average of at least 10 cigarettes per day during the last 12 months while nonsmokers were persons who had smoked fewer than 2 cigarettes in their lifetime. The fifty smokers were randomly assigned to two groups (i.e., nondeprived smoking group and deprived smoking group). Individuals in the nondeprived smoking (NDS) group were asked to smoke as normal and to consume one cigarette immediately before they came to the laboratory. Individuals in the deprived smoking group (DS) were required to abstain from smoking over-night for about 12 h prior to their appointments.

Most participants were students from the University of Würzburg receiving either money (6 euro/h) or course credit. Deprived smokers were compensated with extra 10 euro for their efforts to abstain from smoking.

4.2.2 Materials

The picture stimuli were the same as that in Experiment 2. In total 125 pictures (including 25 neutral scenes, 50 positive scenes and 50 negative scenes) from the International Affective Picture System (IAPS; Lang et al., 2005) were used[1]. Each picture was displayed at a size of 600 pixels in height and 800 pixels in width on the computer screen at a viewing distance of 60 cm using Presentation software (Neurobehavioral Systems, Albany, CA).

Auditory instructions (‘maintain’ and ‘decrease’) were recorded in advance. However, these instructions were different from preceding studies (Experiments 1 and 2). Half of the emotional pictures (i.e., positive and negative pictures) were preceded by the instruction ‘maintain’ (i.e., to simply attend to the pictures, allowing themselves to experience whatever thoughts and feelings happened during picture-viewing). The other half was preceded by the instruction ‘decrease’ (i.e., to reappraise the emotional pictures in order to feel neutral by imagining that the depicted negative scenario would improve and positive scenario will become negative over time). All of the neutral pictures were preceded by ‘maintain’ forming a baseline condition. The auditory instructions were presented binaurally via speakers with a sound intensity of 68dB.

Similar to Experiment 2, Self-Assessment Manikins (SAM; Lang, 1980; Bradley and Lang, 1994) were used to measure stimulus evoked valence, arousal and craving to smoke. Portable smokerlyzer CO monitor was used to measure the CO level. The Questionnaires, including the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker & Fagerstrom, 1991), the German version of the State Trait Anxiety Inventory questionnaire (STAI; Laux, Glanzmann, Schaffner, and Spielberger, 1981), the German version of the Beck Depression Inventory questionnaire (BDI; Hautzinger et al., 1995) and the German version of the Emotion Regulation questionnaire (ERQ, Gross & John, 2003), were used to measure the degree of smoking dependence, depressive and anxiety symptoms and daily life emotion regulation strategies, respectively.

4.2.3 Procedure and Apparatus

All experimental sessions were conducted between the hours of 12:30 pm and 7:00 pm in order to minimize differences in duration of smoking deprivation in DS group.

After reading the instructions for the experiment and signing the written consent, participants completed a simple breath test with a Smokerlyzer® carbon monoxide (CO) monitor to verify their smoking status. Then they completed a screening session that included a general demographics questionnaire, the FTND, the STAI, the BDI and the ERQ.

Participants were then seated in a comfortable chair in a sound attenuated and dimly lit room. The electroencephalograph (EEG) sensors and facial Electromyography (EMG) sensors were attached to the scalp and face, respectively. To decrease demand characteristics, participants were informed that their skin conductance was to be measured as they viewed some pictures. Three initial practice trials were given to explain the procedure. Next, the experimental session started, consisting of 125 trials with 25 trials for each of the five experimental conditions: neutral pictures preceded by 'maintain', negative pictures or positive pictures preceded by 'maintain', and negative or positive pictures preceded by 'decrease', respectively (i.e., maintain-neutral, maintain-positive, maintain-negative, decrease-positive, and decrease-negative). The trials were pseudorandomized so that no more than three trials from the same condition were presented successively.

Each trial began with a white fixation cross presented on a black screen for a period ranging randomly from 4 to 5 sec. The fixation cross turned blue, one second before the onset of the auditory instructions (i.e., 'maintain' or 'decrease') that could last for about 1 sec. Following the instruction, there was a 1 sec delay and then the corresponding picture was presented for 6 sec. At the offset of each picture, the SAM scales appeared on the screen and participants rated how they felt during picture presentation. There were breaks after every 25 trials. The whole experimental session lasted about 40 min.

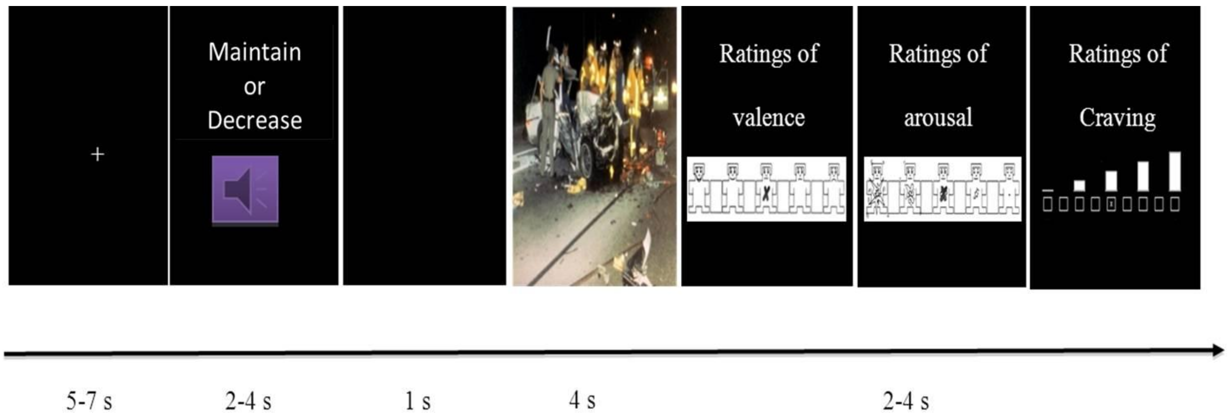


Figure 9. An example of one trial for the Experiment 3.

4.2.4 Psychophysiological data recording

The recoding procedure was almost the same as that of the Experiment 2. The continuous EMG and EEG were recorded at 1000 Hz through a V-Amp 16 amplifier (Brain Products Inc., Gilching, Germany). Facial electromyographic (EMG) activity was measured over the corrugator and zygomaticus muscle regions. The EEG was recorded using an EasyCap (EasyCap, Hersching, Germany) from 10 positions including FCz, Cz, CPz, Pz, C1, C2, CP1, CP2 and the left and right mastoids. Vertical EOG was recorded from electrodes placed 1 cm above and below the right eye, and horizontal EOG was recorded with two electrodes 1 cm from the outer epicanthus of each eye. FCz was used as ground. Reference was placed at Cz during data recording. Impedance was kept below 10 kΩ at all sites (see figure 5).

4.2.5 Data Reduction

Off-line analyses of the EMG and EEG activity were conducted with Brain Vision Analyzer Software (Version 2.0, Brain Products Inc., Gilching, Germany)[11]. The basic procedure was the same as in Experiment 2. 10 participants were excluded from data reduction and further analysis because of technical errors which resulted in a lack of markers in the raw EEG data. As a result, a total of 23 nonsmokers (12 females), 22 nondeprived smokers (12 females) and 20 deprived smokers (10 females) were included in data analyses (see Table 2 for demographic characteristics).

4.2.6 Statistical analyses

Multivariate analyses (MVA) were conducted to test for differences among nonsmokers, nondeprived smokers, and deprived smokers in questionnaire scores.

A manipulation check was conducted to test whether the participants responded differently to neutral, negative and positive pictures. I selected the baseline condition (i.e., maintain-neutral) and two other conditions during which pictures were matched with emotion consistent instructions (i.e., maintain-positive, maintain-negative). Repeated ANOVA analyses were then conducted with condition (maintain-neutral, maintain-positive, decrease-positive, maintain-negative, and decrease-negative) as a within-subjects factor and group (NS, NDS, DS) as a between-subjects factor. Dependent variables included self-reports and psychophysiological responses. Paired *t*-tests were performed to further examine main effects.

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[11] On average 4.51% of the trials were rejected due to artifacts which left an average of 23.87 trials per subject and per condition.

Effects of reappraisal (i.e., maintain, decrease) on subjective experience and psychophysiological responses among smokers and nonsmokers were examined as follows:. Firstly, difference scores were calculated by subtracting data scores of the baseline condition (i.e., maintain-neutral) from each condition. The different scores of the EMG and the EEG activity were then submitted to a repeated analysis of variance (ANOVA) with picture valence (positive, negative) and reappraisal (decrease, maintain) as within-subject factors, and group (NS, NDS, DS) as a between-subjects factor. Dependent variables included self-reported valence, self-reported arousal, self-reported craving, corrugator activity, and LPP. Paired *t*-tests were conducted to further examine main effects.

For corrugator, zygomaticus and LPP activity, however, I first performed a priori tests based on the following specific hypotheses. For corrugator activity, I expected enhanced activity in the maintain-negative compared to the decrease-negative condition; for zygomaticus activity, I expected enhanced activity in the maintain-positive compared to the decrease-positive condition; for LPP activity, I expected enhanced activity in the maintain-negative compared to the decrease-negative condition, and enhanced activity in the maintain-positive compared to the decrease-positive condition. I did not expect effects of negative and positive emotions on zygomaticus and corrugator activity, respectively. And although this null hypothesis cannot be tested, I exploratively performed *t*-tests comparing these conditions.

Moreover, to address the issues including whether self-reported craving to smoke and emotional responses are simultaneously changed, the multiple measures (i.e., self-ratings, EMG and EEG) are consistent with each other, and participants' performance on emotion regulation is correlated with personal characters (e.g., anxiety as indexed by STAI scores), difference scores were calculated by subtracting data scores under the conditions with 'decrease' instructions (decrease-positive, decrease-negative) from corresponding conditions with 'maintain' instructions (maintain-positive, maintain-negative). The difference scores were then submitted to correlation analysis.

For all analyses the alpha-level was set at .05. The Greenhouse-Geisser correction was applied when the assumption of sphericity was violated. The uncorrected degrees of freedom and effect sizes (partial eta-squared, η^2_p) are reported.

4.3 Results

4.3.1 The demographic characteristics of participants

The demographic characteristics of participants are depicted in Table 2. Multivariate analyses (MVA) indicated that comparing to deprived smokers, nondeprived smokers had higher CO level (F (1, 40) = 64.90, p < .01, η^2_p = .62). None of the other comparisons between the DS group and NDS group reached statistical significance (*p*s > .22). In addition, no significant differences were found between the NS group and the NDS group (or DS group) for age, ERQ score, BDI score, and STAI score (*p*s > .19).

Table 2. Experiment 3: Means (and standard deviations) of the demographic characteristics of participants.

Participant characteristics	Nonsmoker (*n* = 23)	Nondeprived smoker (n = 22)	Deprived smoker (n = 20)
Age (yrs.) [a]	23.35 (2.82)	24.14 (3.30)	25.50 (7.24)

Carbon monoxide (CO) [b]	1,17 (1,03)	17,18 (6,86)	4,10 (2,47)
Cigarettes per day [a]	N/A	16,82 (4,22)	13,95 (4,82)
age to start smoking [a]	N/A	15,73 (2,12)	17,65 (4,12)
history of smoking (yrs.) [a]	N/A	8,41 (3,69)	7,85 (4,74)
Fagerström Test for Nicotine Dependence (FTND) [a]	N/A	4,18 (1,68)	2,75 (2,07)
Emotion regulation questionnaire (ERQ, reappraisal) [a]	26,35 (8,25)	24,86 (7,89)	25,05 (7,98)
Emotion regulation questionnaire (ERQ, suppression) [a]	15,52 (5,16)	12,55 (6,04)	14,75 (5,38)
STAI-trait [a]	37,26 (9,75)	35,73 (7,17)	38,80 (9,17)
STAI-state [a]	35,04 (7,00)	33,86 (6,68)	36,95 (11,39)
Beck Depression Inventory (BDI) [a]	5,70 (5,94)	8,18 (8,83)	8,20 (6,55)

4.3.2 Manipulation check

The ANOVA revealed a significant main effect of condition for the following dependent variables[12]: self-reported valence (F (2, 124) = 401.47, $p < .01$, $\eta^2_p = .87$); self-reported arousal (F (2, 124) = 136.67, $p < .01$, $\eta^2_p = .69$); corrugator activity (F (2, 114) = 32.16, $p < .01$, $\eta^2_p = .34$); zygomaticus activity (F (2, 124) = 21.18, $p < .01$, $\eta^2_p = .26$). However, the main effect condition was not significant for self-reported craving (F (2, 124) = 1.45, $p > .05$, $\eta^2_p = .02$), and LPP activity (F (2, 124) = 1.72, $p = .18$, $\eta^2_p = .03$).

Follow-up *t*-tests indicated that participants responded to the maintain-negative condition with more negative self-ratings (t (64) = 20.00, $p < .01$), higher level of self-reported arousal (t (64) = 15.18, $p < .01$), larger LPP activity (t (64) = 2.02, $p < .05$), and larger corrugator supercilii activity (t (64) = 4.41, $p < .01$) compared to the maintain-neutral condition;participants responded to maintain-positive condition with more positive self-ratings (t (64) = -15.48, $p < .01$), higher level of self-reported arousal (t (64) = 9.13, $p < .01$), smaller corrugator supercilli activity (t (64) = -5.09, $p < .01$), and larger zygomaticus activity (t (64) = 4.69, $p < .01$) again compared to the maintain-neutral condition.

There was also a significant main effect of group on self-reported craving (F (2, 62) = 36.94, $p < .01$, $\eta^2_p = .54$). Post-Hoc tests indicated that compared to the NS group, participants in the NDS group and DS group reported significantly larger craving to smoke (NDS: $p < .01$; DS:

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[12] The means and standard error of self-ratings, EMG activities and LPP activities to each of the three emotion-congruent conditions by the NS group, NDS group, and the DS group are depicted in appendix 4.

$p < .01$), while the difference between the NDS group and DS group did not reach statistical significance ($p = .45$). None of the interactive effects reached statistical significance (ps > .12).

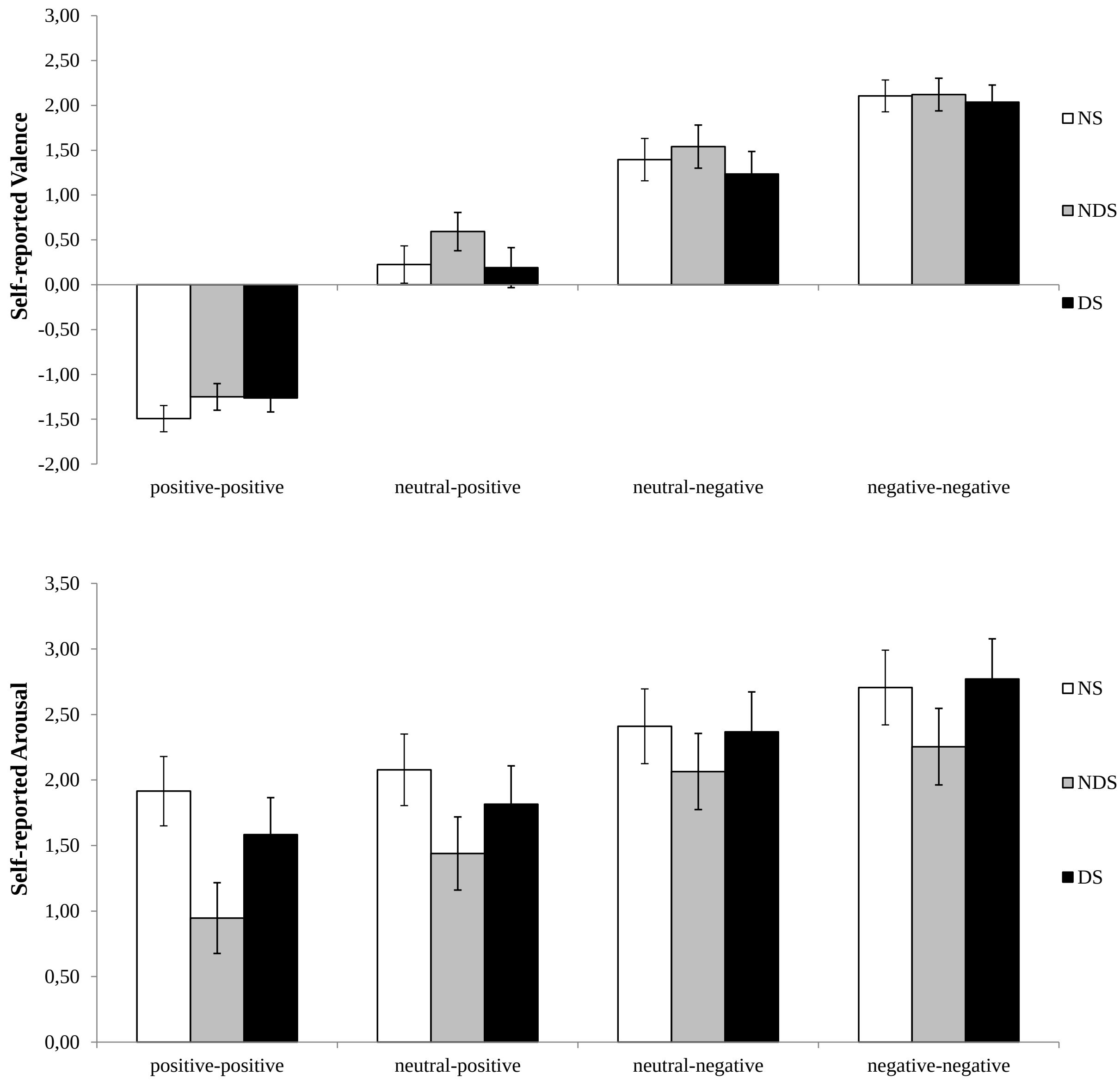
4.3.3 Effect of reappraisal on self-reported valence, arousal and craving in smokers and nonsmokers

Mean changes in self-reports depending on conditions are shown in Figure 10.

Self-reported valence. The ANOVA revealed main effects of picture valence (F (1, 62) = 238.99, $p < .01$, $\eta^2_p = .79$) and reappraisal (F (1, 62) = 48.55, $p < .01$, $\eta^2_p = .44$). The main effect of group was not significant (F (2, 62) = 1.34, $p = .27$, $\eta^2_p = .04$). There was a significant interaction effect of picture valence by reappraisal (F (1, 62) = 92.80, $p < .01$, $\eta^2_p = .60$). Paired t-tests showed that the maintain-negative condition was rated as more negative than the decrease-negative condition (t (64) = 5.46, $p < .01$). Moreover, the maintain-positive condition was rated as more positive than the decrease-positive condition (t (64) = -11.09, $p < .01$). None of the other interaction effects reached statistical significance (ps > .22).

Self-reported arousal. The ANOVA revealed main effects of picture valence (F (1, 62) = 70.40, $p < .01$, $\eta^2_p = .53$). The main effect of group was not significant (F (2, 62) = 1.58, $p = .21$, $\eta^2_p = .05$), so as the main effect of reappraisal (F (1, 62) = 0.00, $p = 1.00$, $\eta^2_p = .00$). There was a significant interaction effect of picture valence by reappraisal (F (1, 62) = 18.27, $p < .01$, $\eta^2_p = .23$). Paired t-tests showed that the maintain-negative condition was rated as more arousing than the decrease-negative condition (t (64) = 3.24, $p < .01$), and maintain-positive condition was rated as less arousing than decrease-positive conditions (t (64) = - 2.13, $p < .05$). However, there was no reliable difference between positive-positive and neutral-positive conditions (t (19) = 0.58, $p = .57$). None of the other interaction effects reached statistical significance (ps > .19).

Self-reported craving. The ANOVA showed that none of the main effects and interaction effects reached statistical significance (*p*s >.18).



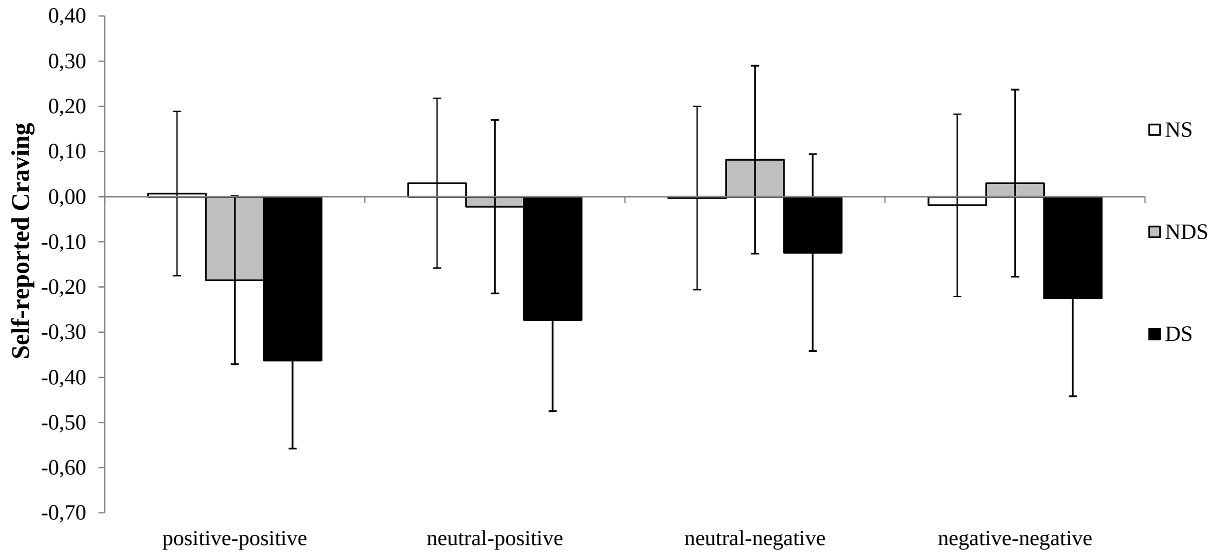


Figure 10. Effect of reappraisal on ratings of valence and arousal across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS). Depicted are changes in self-reported valence (top), self-reported arousal (middle) and self-reported craving (bottom) as a function of reappraisal among the three groups of participants. Each bar represents the difference score between one of the four conditions (maintain-positive, decrease-positive, decrease-negative, and maintain-negative) and the neutral condition. Error bars represent standard error of the mean (SEM).

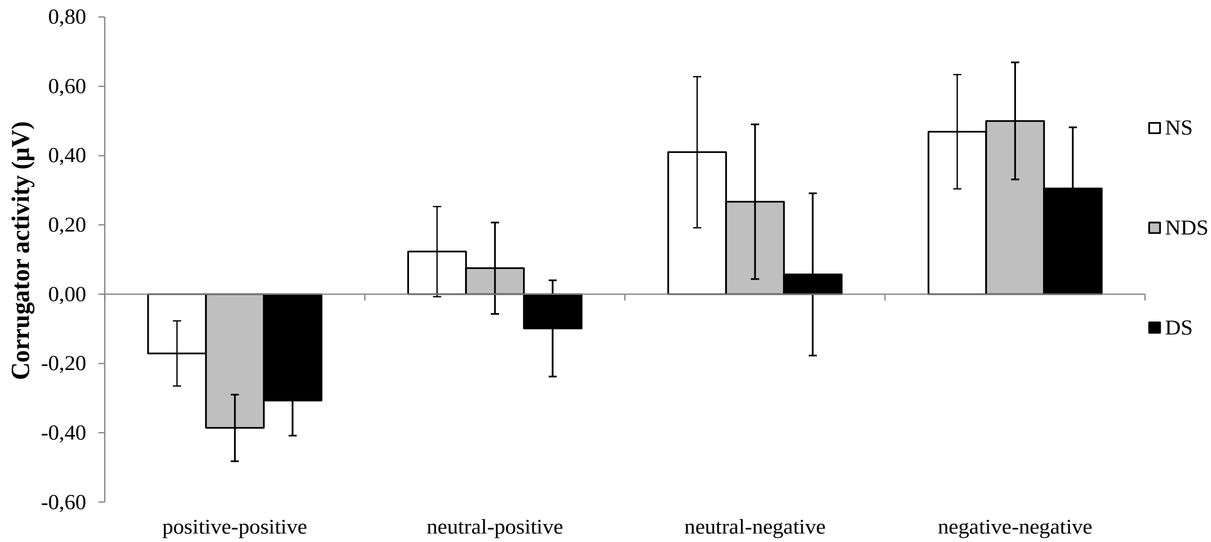
4.3.4 Effect of reappraisal on psychophysiological responses in smokers and nonsmokers

Mean changes in EMG activity and LPP activity are shown in Figure 11 and Figure 12, respectively.

Corrugator activity. The a priori *t*-tests showed that corrugator activity was higher in the maintain-negative condition compared to the decrease-negative condition (t (64) = 2.00, p < .05). The exploratory comparison of the corrugator activity between the maintain-positive and decrease-positive conditions also reached statistical significance (t (64) = -3.74, p < .01). The ANOVA revealed a significant main effect of picture valence (F (1, 62) = 37.56, p < .01, η^2_p = .38), but neither main effect of reappraisal (F (1, 62) = 1.04, p = .31, η^2_p = .02) nor main effect of group (F (2, 62) = 0.71, p = .50, η^2_p = .02) reached statistical significance. There was a significant interaction effect of picture valence by reappraisal (F (1, 62) = 21.04, p < .01, η^2_p = .25). No other interaction effects reached statistical significance (*p*s > .31).

Zygomaticus activity. The a priori *t*-tests showed that zygomaticus activity was higher in the maintain-positive than the decrease-positive condition (t (64) = 4.49, p < .01). The exploratory comparison of the zygomaticus activity between the maintain-negative condition compared to the decrease-negative conditions failed to reach statistical significance (t (64) = -0.35, p = .73). The ANOVA revealed a significant main effect of picture valence (F (1, 62) = 25.03, p < .01, η^2_p = .29), and main effect of reappraisal (F (1, 62) = 18.94, p < *.01*, η^2_p = .23). The main effect of group (F (1, 62) = 0.09, p = .91, η^2_p = .00) was not significant (F (2, 62) = 1.65, p = *.20*, η^2_p = .05). There was a significant interactive effect of picture valence by reappraisal (F (1, 62) = 15.11, p < .01, η^2_p = .20). None of the other interaction effects reached statistical significance (*p*s > .16).

LPP activity. The a priori *t*-tests revealed that LPP activity was larger in the maintain-negative than the decrease-negative conditions (t (64) = 2.02, p < .05). The a priori *t*-test comparing the maintain-positive condition compared to the decrease-positive condition was not significant (t (64) = -0.23, p = .82). The ANOVA revealed that none of the main effects and interaction effects reached statistical significance (ps > .22)[13].



[13] A repeated ANOVA analyses with condition (neutral-negative and negative-negative) as a within-subjects factor and group (NS, NDS, DS) as a between-subjects factor was conducted to further investigate how the three groups differ on emotion regulation via the appraisal frames. The results revealed a significant main effect of condition (F (1, 62) = 4.34, p < .05, η^2_p = .07). Neither the main effect of group (F (2, 62) = 1.69, p = *.20*, η^2_p = .05) nor the interactive effect of condition by group was significant (F (2, 62) = 1.42, p = .25, η^2_p = .04). Paired t-tests showed that LPP activity was significantly greater under the negative-negative condition than the neutral-negative condition among the NS group (t (22) = 1.88, p < .05) and among the DS group (t (19) = 2.23, p < .05), but not the NDS group (t (21) = 0.06, p = .48).

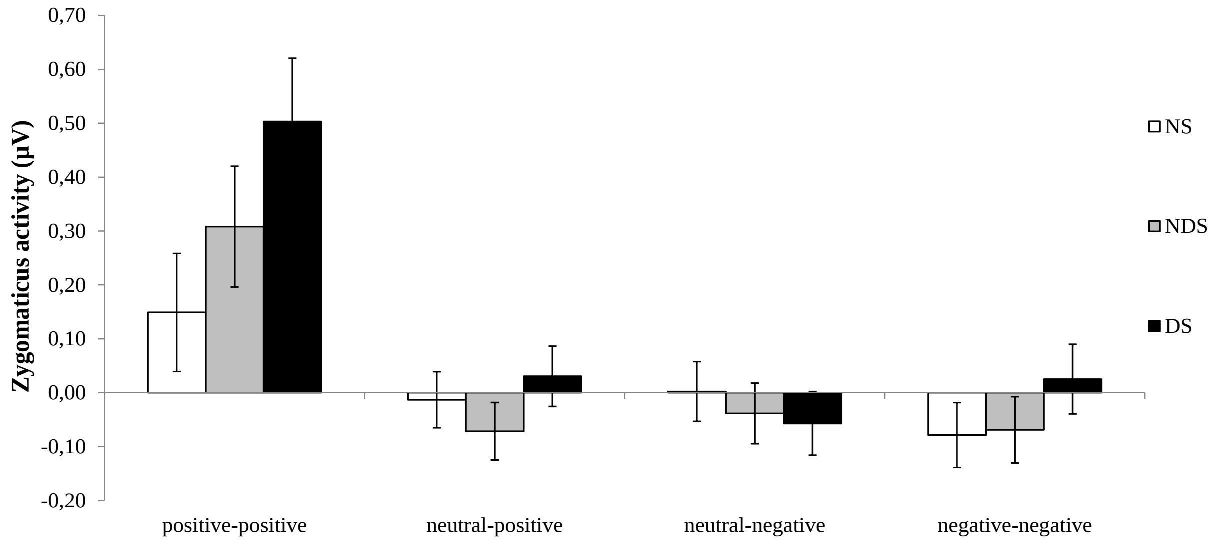
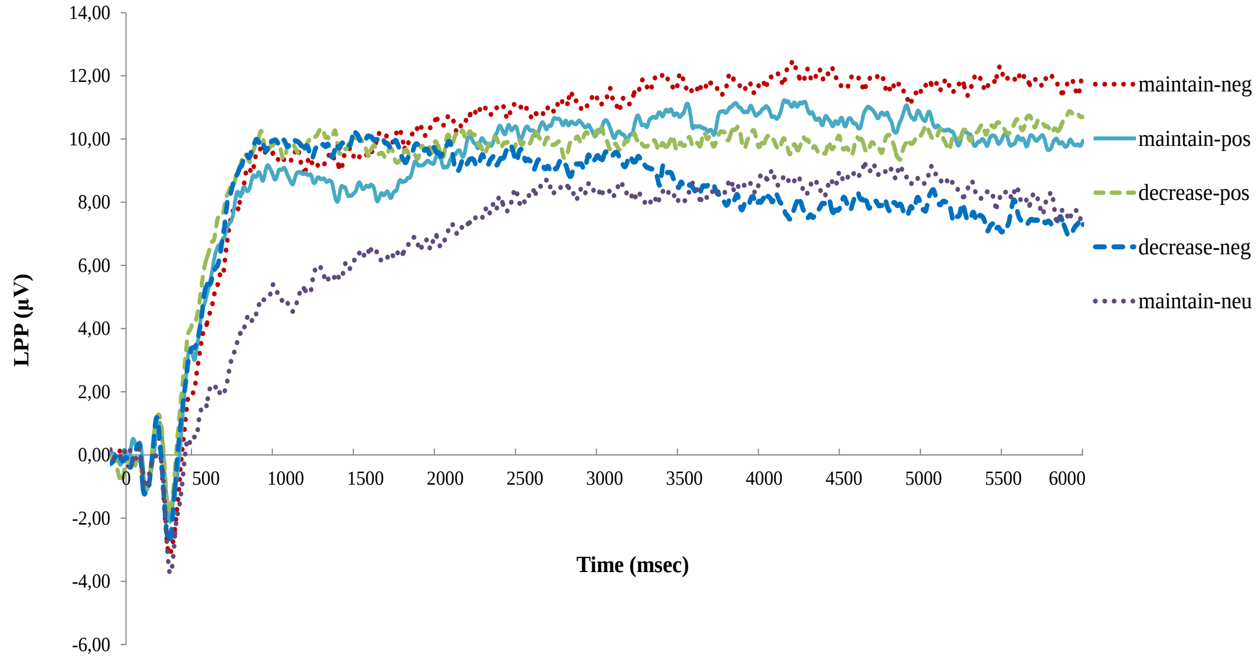


Figure 11. Effect of reappraisal on facial EMG activity across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS). Depicted are changes in corrugator activity (top) and zygomaticus activity (bottom) as a function of reappraisal of the three groups of participants. Each bar represents the difference score between one of the four conditions (maintain-positive, decrease-positive, decrease-negative, and maintain-negative) and the neutral condition. Error bars represent standard error of the mean.



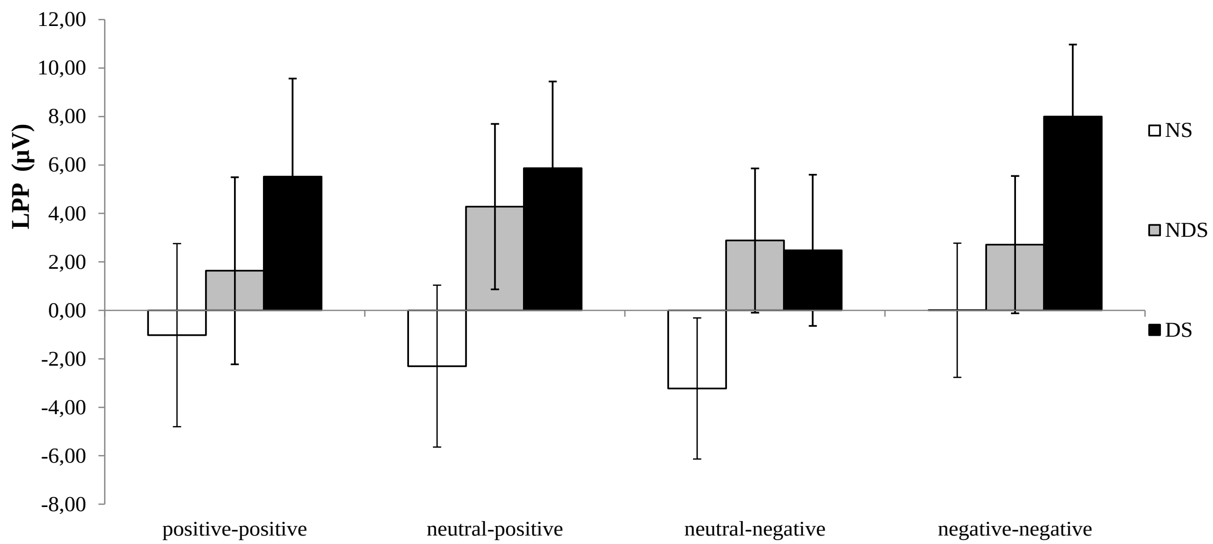


Figure 12. Dynamic changes in LPP activity (top) and the effect of reappraisal on LPP activity across nonsmokers (NS), nondeprived smokers (NDS) and deprived smokers (DS)

(bottom). Top: Depicted are grand averaged ERPs during the time window from 0 to 6 s per condition at central–parietal recording sites elicited by each condition: Neutral pictures were associated with neutral narratives (green solid line); negative pictures were preceded by either a negative narrative (dark blue dotted line) or neutral narrative (red dashed line); positive pictures were preceded by either a positive narrative (light blue dotted line) or neutral narrative (purple dashed line). Bottom: Depicted are changes in LPP activity as a function of reappraisal across the three groups of participants. Each bar represents the difference score between one of the four conditions (maintain-positive, decrease-positive, decrease-negative, and maintain-negative) and the maintain-neutral condition. Error bars represent standard error of the mean (SEM).

4.3.5 Correlations of multiple measurements

There was a significant positive correlation between self-reported valence and self-reported arousal irrespective of the valence of emotional stimuli. The larger changes in self-reported valence as a result of reappraisal, the greater changes in self-reported arousal were observed (N = 65; positive stimuli, $r = .64$, $p < .01$; negative stimuli, $r = .27$, $p < .05$). The self-reported craving was also positively correlated with the modulation of self-reported arousal with respect to the negative stimuli (N = 65; $r = .42$, $p < .01$) and the positive stimuli (N = 65; $r = .30$, $p < .01$). The corrugator activity was negatively correlated with zygomaticus activity with respect to the positive stimuli (N = 65; $r = -.41$, $p < .01$), but not to the negative stimuli (N = 65; $r = .14$, $p = .28$). The LPP activity was positively correlated with self-reported valence in terms of the positive stimuli (N = 65; $r = .25$, $p < .05$). Moreover, the LPP activity was negatively correlated with FTND scores (N = 65; $r = .33$, $p < .05$) and cigarettes per day (N = 65; $r = -.38$, $p < .05$) in terms of the negative stimuli, meaning that the more the smokers depended on smoking, the smaller changes in the LPP amplitude were observed as a function of reappraisal.

4.4 Discussion

The present experiment aimed to further examine: 1) whether emotional (i.e., negative and positive) pictures evoke comparable emotional responses among nonsmokers, nondeprived smokers, and deprived smokers; 2) whether the three groups of participants differ in emotion regulation via cognitive reappraisal; 3) whether smokers' emotional responses and their cravings to smoke are simultaneously altered by reappraisal; 4) whether self-reported emotions are consistent with psychophysiological responses as indexed by facial EMG and LPP activity.

First, the present study replicated the results of Experiment 2 as the emotional pictures evoked comparable emotional responses among all participants. As expected, compared to maintain-neutral condition, maintain-negative condition evoked more negative emotions (i.e., more negative self-reported valence, higher arousal level, larger corrugator activity, and enhanced LPP activity); and maintain-positive condition evoked more positive emotions (i.e., more positive self-reported valence, higher arousal level, greater zygomaticus activity, and larger LPP activity). There was no significant difference between the three groups, suggesting that smokers respond to emotional pictures in a similar way as nonsmokers, and deprivation of smoking does not affect smokers' emotional responses.

Robinson & Berridge (1993) have formulated a contemporary theory of addiction called the Incentive Sensitization Theory of Addiction. The main point of this theory is that drug addiction develops from a sensitization of the mesolimbic dopamine system, as consequence such sensitization determines hypersalience of drug-associated stimuli and hypoactive response to nondrug-associated stimuli depicting normal rewards (Robinson & Berridge, 1993; Goldstein & Volkow, 2011). However, the results of this study do not support this theory, as I found that all smokers (both nondeprived smokers and deprived smokers) and nonsmokers do not differ in their responses to non-cigarettes-related affective stimuli. Further studies that compare smokers and nonsmokers on emotional responses to cigarettes-related stimuli are needed.

Secondly, as for appraisal frame strategies, I did not find group differences on emotion regulation via reappraisal. Emotional experiences and psychophysiological responses of all smokers and nonsmokers were effectively altered as required by reappraisal instructions. The down regulation conditions (i.e., emotional pictures matched with 'decrease' instruction) evoked reduced emotional responses compared to maintaining conditions (i.e., emotional pictures matched with 'maintain' instruction). Accordingly, it is concluded that despite the high cognitive effort in the reappraisal strategy, smokers are as able as nonsmokers to use reappraisal to regulate emotions.

The only group difference that I found was in participants' self-reported craving. In fact, smokers reported significantly greater cravings to smoke than nonsmokers, irrespective of the valence of emotional stimuli. Deprived smokers and nondeprived smokers did not differ in their self-reported cravings to smoke across all conditions. Initially this result was quite surprising considering that I expected that no-deprived smokers might have performed better regulation of their craving. However, this result may be attributed to their heavy dependence on nicotine and a relatively short period of smoking abstinence. Furthermore, the current study showed that smokers' emotional responses and their craving to smoke were not simultaneously altered by reappraisal. Reappraisal instructions did not change self-reported craving despite the successful regulation of the emotional responses to the pictures. Notably, changes in self-reported emotional arousal correlated positively with individual craving with regard to both the negative and the positive stimuli. Therefore, it is plausible to conclude that smokers' craving to smoke is quite stable; and the smoking craving may be more influenced by the emotional arousal as opposed to the emotional valence.

Finally, the results of this study demonstrated that emotional experience and psychophysiological responses are not consistently modified by reappraisal. Greater changes were noted in self-reported emotions as compared to psychophysiological responses. A potential explanation is that different measures are subjected to different types of errors. For example, subjective ratings are more likely to be influenced by cognitive demand characteristics than facial EMG activities and EEG activities (Ray et al., 2010). To explore the reason for the inconsistency, further studies are needed to explore mechanisms and/or informational processes underlying emotion generation and regulation across channels.

5. General discussion and conclusion

The major aim of this thesis was to test whether smokers present impaired cognitive emotion regulation. To address this issue, I adopted two forms of appraisal paradigms (i.e., appraisal frame and reappraisal) to compare emotional responses (negative and positive emotions) of smokers with that of nonsmokers as a function of appraisal strategies.

Although both the prospective (i.e., appraisal frame) and the retrospective (i.e., reappraisal) manipulations of appraisal process are important emotion regulation strategies in our daily life, prior research mainly focused on the effect of reappraisal on emotional responses. The results showed that reappraisal is efficient in altering emotional experience, physiological responses including facial expressions and brain electrical activities (Dan-Glauser & Gross, 2011; Gross & Thompson, 2007; Ochsner & Gross, 2008; Ray et al., 2010; Urry, 2009; Hajcak & Nieuwenhuis, 2006). The effect of appraisal frames has not been well studied. Only a few recent studies addressed this issue. The results showed that appraisal frames were efficient in altering emotional responses to negative stimuli, including self-reports and brain electrical activities as indexed by EEG amplitude (Foti & Hajcak, 2008; MacNamara, Ochsner & Hajcak, 2011; Dennis & Hajcak, 2009). However, it was not clear whether appraisal frames can regulate facial expression that is an important channel of nonverbal communication and one major outcome of emotion regulation, particularly with regard to positive stimuli.

Therefore, to fill in the gap, the first experiment of this thesis addressed the question whether and how appraisal frames of picture stimuli affect emotional experience and facial expression. Participants were exposed to auditory appraisal frames preceding positive and negative picture stimuli. Ratings of valence and arousal as well as facial EMG activity over the corrugator supercilii and the zygomaticus major muscle were measured simultaneously. The results showed that the prospective manipulation of interpretations of emotional stimuli could alter both subjective emotional experience and facial expression, irrespective of the valence of the pictorial stimuli. This is the first study that reveals the efficacy of appraisal frames in altering facial EMG activity and subjective experience in the context of negative stimuli and in particularly of positive stimuli. The results are consistent with the findings of prior EEG studies (e.g., Foti & Hajcak, 2008; Dennis, Hajcak, 2009), suggesting that appraisal frame is an efficient paradigm in regulation of multi-level emotional responses.

The second experiment applied the appraisal frame paradigm to explore how smokers differ from nonsmokers on cognitive emotion regulation. Smokers were divided into a nondeprived smoking group and 12-h deprived smoking group in order to examine the effect of nicotine dependence and short-term smoking abstinence on cognitive emotion regulation. Prior work including both theoretical models of addiction (e.g., self-regulation failure theory) and experimental studies have implicated that nicotine addiction are associated with less frequent use of appraisal strategies and more self-regulation failures than nonsmokers (Baumeister & Heatherton, 1996; Yucel et al., 2007; Szasz et al., 2012; Fucito et al., 2010; Baker et al., 2004; Magen & Gross, 2007; Erskine, Ussher, Cropley, 2012). Accordingly, it was hypothesized that smokers would show deficit in cognitive emotion regulation. In particular, I expected smaller changes in emotional responses of smokers than of nonsmokers as a result of appraisal frames. However, the results demonstrated that nondeprived smokers and deprived smokers were as good as nonsmokers on the emotion regulation task. The lack of group differences in multiple emotional responses (i.e., self-reports, facial EMG activity and brain EEG activity) suggested that nicotine addicts could regulate their emotions via appraisal frames.

Considering that the emotion regulation primed by appraisal frames is relatively easy as compared to reappraisal, a third experiment further explored smokers' emotion regulation ability by comparing performances of smokers and nonsmokers in a reappraisal task. Participants were instructed to regulate emotions by imagining that the depicted negative scenario would improve or that the positive scenario would become negative over time. Participants self-generated reinterpretations of emotional stimuli during the viewing of emotional pictures. The results showed that nondeprived smokers and deprived smokers performed as well as nonsmokers in down-regulating positive and negative emotions via the reappraisal strategy.

In sum, the results of this thesis indicated that nicotine addicts do not have deficit in emotion regulation using cognitive appraisal strategies. All participants (nonsmokers, nondeprived smokers and deprived smokers) were capable of regulating positive and negative emotions following instructions of appraisal frame paradigm and reappraisal paradigm as well. In other words, smokers may maintain the cognitive ability to regulate positive and negative emotions via appraisal strategies.

So far, no prior work has been done to examine emotion regulation in drug addicts via appraisal strategies. In the field of drug addiction, previous studies have applied reappraisal strategies to examine craving regulation in drug addicts, particularly in nicotine addicts. It has been found that smokers reduced craving to smoke when they were asked to think about the long-term effects of smoking (Kober, Kross, Mischel, Hart & Ochsner, 2010; Kober et al., 2010; Szasz et al., 2012). However, craving regulation and emotion regulation have been associated with separable brain regions and changes in craving are not bound to changes in emotion, and vice versa (Born et al., 2011; Berridge, 2007, 2009, 1996; Koob & Moal, 2006). It was unknown whether smokers are capable to regulate emotional responses as well as cravings to smoke by appraisal strategies.

This thesis is the first to investigate cognitive emotion regulation via appraisal strategies in the field of drug addiction. The results do not support the hypothesis that smokers have deficit in applying appraisal strategies to regulate emotions. According to theoretical models of nicotine addiction (e.g., self-medication model and self-regulation failure model), people develop addiction to nicotine because they experience accumulating self-regulation failures and expect that smoking can help reduce negative emotions (Baumeister & Heatherton, 1996; Yucel et al., 2007; Khantzian, 1985, 1997). Regular smokers have been associated with frequent use of maladaptive emotion regulation strategies (e.g., suppression) and less frequent use of appraisal strategies in daily life, together with abnormal PFC function which are important for cognitive emotion regulation (Gonzalez et al., 2008; Fucito, Juliano & Toll, 2010; Szasz et al., 2012; Baker et al., 2004; Magen & Gross, 2007; Erskine, Ussher, Cropley, 2012).

The inconsistence might be attributed to some major differences between the laboratory environment and the real-life situation. Firstly, emotional stimuli in the real-life situation in general could be more self-relevant and more intensive than the pictorial stimuli in the present thesis. The deficit in emotion regulation in nicotine addicts may not be detected in laboratory environment when emotions evoked by pictures from the IAPS are mild and easy to handle. Secondly, according to the incentive salience theory of addiction, smoking-related stimuli become more salient and smokers are hyper-responsive to those stimuli (Robinson & Berridge, 1993, 2008). However, all stimuli used in the present thesis are representative of natural rewards. Smoking-related stimuli were not included in the current studies. The present thesis showed that smokers have intact ability to regulate emotions in general. It is unknown if they have deficits in regulating emotional responses to smoking-related stimuli[14]. Lastly and most importantly, in the present study, all participants were specifically instructed to regulate emotions using appraisal strategies. However, this is not the case for real life situation in which individuals often have to decide by themselves when to regulate emotion and which regulation strategy to be used. Therefore, self-regulation failures proposed by theoretical models and frequent use of maladaptive emotion regulation strategies in nicotine addicts indicated by clinical or survey studies might be attributed to their wrong selection of maladaptive strategies in the context of emotion regulation vulnerability, rather than a lack of cognitive ability to regulate emotions via appraisal strategies. Supportively, imaging studies have shown that nicotine addicts are associated with abnormal functions in PFC brain regions (Goldstein & Volkow, 2011; Zhang et al., 2010; Sutherland et al., 2012); and those regions are involved in decision making as well as in emotion regulation (Yucel et al., 2007; Bechara et al., 2001). To expand the conclusion, it will be interesting for future studies to investigate how smokers differ from nonsmokers on spontaneous selection of regulation strategies in the context of emotion regulation vulnerability.

An additional aim of this study was to verify the effect of smoking deprivation on emotional responses and emotion regulation as compared to regular smokers. Prior work showed that deprived smokers performed less well on a variety of cognitive tasks such as attention, memory, and affective processing as compared to nondeprived smokers (Gilbert et al. 2007, 2008). It was assumed that smokers could be impaired in cognitive ability to regulate emotion

[14] A pilot study has been done to determine if deprived smokers and nondeprived smokers have deficits in using appraisal strategies to regulate emotional responses to smoking-related stimuli. The results showed that all smokers can successfully reduce their positive emotions evoked by cigarette pictures as a function of reappraisal. These findings will be reported in another paper.

with appraisal strategies, and smoking deprivation may worsen the deficit. However, the results demonstrated that deprived smokers performed as well as nondeprived smokers when they were instructed to regulate emotions using cognitive appraisal strategies, suggesting that overnight abstinence from smoking do not affect the cognitive ability to regulate emotions. The findings further confirmed the conclusion that nicotine may not affect emotional processing or emotion regulation ability.

This thesis also aimed to compare regulation of positive emotions with regulation of negative emotions. Although regulation of positive emotions has been highly correlated with cognitive/affective function, social communication and human well-being (Fredrickson, 2001; Fredrickson et al., 2008; Winkler et al., 2011; Geier et al., 2000; Conzelmann et al., 2010, 2011), most of prior work in the field of emotion regulation focused on alteration of negative emotions (McRae et al., 2010; Parvaz et al., 2012; Mocaiber et al., 2011; Johnstone et al., 2007; Ochsner et al., 2002; Ochsner et al., 2004; Ochsner & Gross & Thompson, 2007). Little has been known about regulation of positive emotions via appraisal strategies (Giuliani et al., 2008, Krompinger et al., 2008; Delgado et al., 2008). The present study expanded previous studies by investigating cognitive emotion regulation in terms of both positive and negative stimuli. The results showed that with respect to the negative emotions, appraisal strategies successfully reduced self-ratings of unpleasantness, corresponding facial EMG activity over corrugator muscle, as well as subjective arousal and corresponding LPP activity. However, with respect to the positive emotions, appraisal strategies decreased self-reported pleasantness and facial EMG activity over zygomaticus major muscle, but failed to change self-reported arousal and LPP activity. These results suggest that changes of emotional valence and arousal as a function of appraisal strategies are congruent in the context of negative picture stimuli but incongruent in the context of positive picture stimuli. Supportively, it has been noted that the more negative stimuli evoked more unpleasant and more arousing self-reports; whereas in the dimension of positive stimuli, the more positive stimuli might be linked with either higher arousal ratings or lower arousal ratings (Lang, 2005). A potential explanation is that reducing negative emotions is probably more necessary and is more practiced than down-regulation of positive emotions in the daily lives of human beings. Therefore, it should be cautious for future studies to differentiate valence and arousal when addressing regulation of positive emotions. To expand the findings, future studies are needed to further investigate the cognitive and neural mechanisms underlying the regulation of positive and negative emotions depending on their arousal level.

Finally, this thesis combined multiple measurements to verify cognitive emotion regulation ability among smokers and nonsmokers. The results consistently showed that self-reported emotional experience is the most vulnerable variable to cognitive emotion regulation, whereas physiological responses including facial EMG activity and brain electrical activity were less altered by appraisal strategies. A potential explanation is that ratings are more likely to be consciously altered by cognitive demand characteristics than physiological responses (Ray et al., 2010). Moreover, with regard to self-reported craving to smoke, the present study demonstrated that successful regulation of emotions was not bound to corresponding changes in smoking craving. In particular, nonsmokers reported no craving to smoke at all across each emotion regulation condition; deprived smokers and nondeprived smokers maintained stably higher cravings to smoke as compared to nonsmokers, which was not influenced by appraisal strategies. The results supported my hypothesis that emotion regulation and craving regulation are separable. To draw a more confirming conclusion, it will be important for future studies to investigate cognitive and neural mechanisms underlying the interaction of emotion regulation and craving regulation.

One must be cautious to the limitations of this study. Firstly, the emotional stimuli used in the study are not comparable to daily-life emotional events. Emotional events in real world are highly self-relevant, unpredictable, and overwhelming in comparison with pictorial stimuli used in the laboratory studies. The former may evoke more intense and more arousing emotions than the latter, and thus the performance in the real world cannot be predicted based on the results of this study. Secondly, the participants of this study were in a sort of relaxed and neutral to pleasant mood when they started the experiment[15]. In the real world, however, individuals often need to regulate emotions in an unpleasant mood such as a stressful or anxious state. Moreover, as stated earlier, rather than being instructed or even taught to use appraisal strategies to regulate emotions in the laboratory study, people in real world have to self-initiate emotion regulation and select their own strategies. Therefore, the finding that nicotine addicts have intact ability to regulate emotional responses to pictorial stimuli in the laboratory environment cannot ensure that nicotine addicts are able to regulate emotions evoked by life events in the real world. To expand this conclusion, it will be important for future research to induce negative or positive mood first and then examine individuals' performance on emotion regulation tasks. Furthermore, it will be

[15] In Experiment 2, the three groups of participants did not differ from each other regarding mood state (F (2, 57) = 2.70, p = .08, η^2_p = .09); (NS, M = 2.57, SD = 0.30; NDS, M = 2.68, SD = 0.33; DS, M = 3.56, SD = 0.34). In Experiment 3, the results replicated this finding of the Experiment 2. All participants reported neutral to pleasant mood (F (2, 62) = 1.39, p = .26, η^2_p = .04); (NS, M = 2.83, SD = 0.36; NDS, M = 2.82, SD = 0.37; DS, M = 3.60, SD = 0.39).

interesting to explore how nicotine addicts select emotion regulation strategies as well as how they apply certain type of strategy to regulate emotional responses to emotional events.

In conclusion, the results of this thesis indicated that appraisal frames and reappraisal instructions were efficient in altering emotions of smokers and nonsmokers, irrespective of the valence of the emotion; moreover, deprived smokers and nondeprived smokers performed as well as nonsmokers on the two emotion-regulation tasks. From these results we suppose that nicotine addicts do not have cognitive impairment in emotion regulation via appraisal strategies, although this does not exclude their inability to select and apply appraisal strategies to regulate emotions in real-life situations (e.g., stressful conditions or other high-risk smoking-related situations). The implications of this thesis are two-fold. On the one hand, it establish the ground work for potential therapeutic use of appraisal instructions to deal with self-regulation failures in nicotine addicts; On the other hand, it implicates that psychotherapeutic intervention for nicotine addiction should take into account specific approaches in addition to emotional ones.

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Appendix 1

A. International Affective Picture System (IAPS) Numbers and Corresponding Narratives for Neutral Pictures

IAPS	Neutral Narratives
2102	This man reads the stock report every morning.
2393	These workers are checking the settings of a complicated machine.
2575	This propeller will be used on a small cargo ship.
2580	These men play chess three times a week.
2593	This café has outdoor seating.
5530	This is an edible mushroom.
5740	This plant is common to the northern United States.
7002	This towel was used to clean the f loor.
7004	This spoon is from a 1970s collection.
7010	This woven basket was made to hold fruit.
7056	This wire cutter has many settings.
7090	This book was written in 1950.
7130	This truck has been used by five different companies.
7140	This bus travels a route from Boston to Atlanta.
7150	This is a blue umbrella.
7175	This lamp takes a 60-Watt bulb.
7211	This clock is in the lobby of an office building.
7217	This coat rack is used by three people.
7491	This building was used in a TV sitcom.
7500	This is the office of a large law firm.
7550	This man is working on an old engineering program.
7595	These types of cars were popular in the 1970s.
7700	This is a poster from a work-training video.
7705	This cabinet can hold up to 500 file folders.
7950	These tissues sell for 99 cents.

B. International Affective Picture System (IAPS) Numbers and Corresponding Narratives for Negative pictures

IAPS	Negative narratives	Neutral narratives
1050	This poisonous snake is about to attack.	This snake is harmless and is in a zoo exhibit
1201	A poisonous tarantula is about to bite this man.	This is a harmless pet tarantula sitting on his owner's shoulder.
1302	This is an angry attack dog trained to bite strangers.	This is a dog that has been trained to show its teeth on command.
1930	This is a shark that attacked and killed a diver	This is the mechanical shark from the movie ''Jaws'' .
2120	This is a violent and angry man.	This man has just held his breath for 2 minutes.
2130	This angry woman is yelling at her children.	This woman is about to sneeze.
2141	This woman has just found her mother dead.	These are actresses in a movie called ''The Funeral'' .
2205	This man has just lost his wife to cancer	This man's wife was ill but is fully recovering.
2399	This woman suffers from intense migraine headaches	This is an actress posing for an aspirin commercial.
2661	This premature baby may not live more than a couple of days.	Thanks to early care, this baby develops into a healthy toddler
2683	This is a bloody clash between soldiers and protestors	These are actors in a movie about tension in the Middle East.
2688	The poacher is shooting the bear to sell its fur	A vet is tranquilizing this bear to give him medicine.
2691	This is a protester during a riot where 50 people were killed.	This is a scene from a movie about a riot in the Middle East.
2700	These women are mourning the loss of their close friend.	These women are overwhelmed with joy at a friend's wedding.
2710	This man was found dead from an overdose in a halfway house.	This is an actor from the 1970s film called ''Drug Smuggle".
2716	This man is addicted to crack cocaine.	This man is an actor in a movie about addiction.
2750	This is a homeless man who lives under a bridge in London.	This is an actor who is playing the role of a homeless man
2810	This boy suffers from intense anger problems	This boy is yelling ''Ready or not, here I come'' .
3168	This man suffers from a number of deformities from birth.	The costume worn in this horror film won an Academy Award in 1982.
3220	This man is dying in a hospital	This man is recovering from illness in a hospital
3301	This child was severely injured in a car accident	This child was injured but makes a full recovery.
6020	This is an electric chair used to execute prisoners on death row.	This is a prop from a movie about a man who is on death row.
6190	This woman is about to pull the trigger on her husband.	This is a picture from a training video on gun safety.
6212	This child is about to be shot and killed by a solider	This solider notices the child and does not shoot.
6250	This is a serial killer who has murdered 6 people	This is a poster for an upcoming action movie.
6312	This woman is being abducted by a rapist.	This an actress in a self-defense training video
6313	This man has attacked and mugged this woman	This woman is in a scene from a TV show about inner-city violence.
6570	This man is about to commit suicide	This man ends up not committing suicide.
6571	This man is having his car stolen by a thief	This is a scene from a movie about an undercover cop.
6830	This man is preparing to rob a bank	This is an actor in bank robbery film.
6831	This is a police officer investigating the scene of a murder.	This is the set of a 1960s crime show
8230	This boxer is being sent into a coma.	This is a scene from the movie about boxing.
9042	This man has been punished by his tribe	This tradition is a rite of passage and is actually not painful.
9050	This is a terrible plane crash in which many people were killed.	This plane veered off the runway, but no one was seriously hurt.
9250	These workers have found a war victim.	These doctors will save the woman's life.
9400	This solider was killed in Vietnam.	This is a scene from a movie about Vietnam.
9421	This solider has just lost his best friend in an attack.	This solider is on his way to receive medical attention.

9425	This man has just been taken hostage by terrorists.	This is a scene from a movie called ‘‘The Terrorists’’ .
9470	This building was bombed and 6 people were killed.	This building was condemned and is being demolished.
9490	This man was burned alive in an explosion.	This is a prop from a monster film.
9520	These abandoned children are near a nuclear reactor.	These children are actors in a movie about poverty
9584	This man is undergoing painful dental surgery.	The man is having a routine dental checkup.
9600	This ship sinks and no one survives.	This is a scene from a movie much like ‘‘Titanic’’ .
9611	All passengers were killed in this plane crash.	This fake plane crash was put together for a movie.
9635	This man was set on fire during a civil war	This daredevil sets himself on fire as a stunt.
9800	This is a photo of a German Nazi	This is an actor in a movie about neo-Nazis.
9901	The victims in this accident could not be saved in time.	No one was in this car when it was totaled at a construction site.
9911	The driver in this accident was killed before help could arrive.	This is contrived scene from an educational film about drunk driving.
9920	Two people died in this horrendous car crash.	No one was seriously injured in this car accident.
9921	The firefighters do not save this woman in time.	The firefighters get this woman to safety just in time.

C. International Affective Picture System (IAPS) Numbers and Corresponding Narratives for Positive pictures

IAPS	Positive narratives	Neutral narratives
1463	These kittens are playing happily with each other.	These kittens are staying together.
1710	These cute puppies are waiting for their food.	These cute puppies are standing behind the wall.
1811	These cheerful chimpanzees are laughing.	These chimpanzees are trained to open their mouth.
2080	These babies are quite excited about a new toy.	These babies are taking part in a routine body checkup.
2150	This father is giving a kiss to his new-born baby.	This is an actor in a movie about a single father.
2160	This father is singing a song to his baby after taking a bath.	This is a scene from a training video for parents.
2340	This is a man enjoying spending time with his grandchildren.	This is a scene from the film "When I grow up".
2345	These kids are playing in the sand with a lot of fun.	These kids are posing for an advertisement.
2352	This photo shows a fresh pair of lovers.	This is a poster for a movie about South Africa.
2550	This old couple enjoys their time together.	This is a photo of two wax figures.
2655	This kid is sharing his food with the dog.	This is a photo taken for a commercial ad.
4572	This firefighter keeps his body in a good shape.	This is an actor from a movie about firefighters.
4608	This man is passionately in love with his girlfriend.	This actor mimes a playboy in an upcoming movie.
4623	The couple is enjoying honeymoon vacation.	This is a scene from the film "Newlyweds".
4660	This couple has passionate sex.	This is a scene from a film about a secret affair.
5270	These waterfalls are very beautiful.	These waterfalls emerged after a heavy storm.
5300	This is an amazing scene of the Galaxy.	This image of a galaxy is spoofed
5450	This is a millstone in the exploration of the universe.	This is a routine test for Aerospace instruments.
5460	This astronaut is floating weightless in space.	The astronaut is repairing the instruments in the Space Station.
5480	Fireworks promote a happy festival atmosphere.	Fireworks may contribute to air pollution.
5600	Winter in this region is quite beautiful.	Winter in this region is cold and long-lasting.
5623	Windsurfing is one of the most exciting water sports.	Windsurfing can be dangerous.
5626	This Hang glider pilot enjoys flying through the sky like a bird.	This Hang glider pilot is in a daily training.
5628	This man has scaled the summit of one of the highest mountains.	This man is lagging behind his climbing partner.
5629	This man is about to conquer the highest mountain.	This man is about to quite hiking because he is exhausted.
5660	These mountains are bathed in golden light.	This mountain region has a dry summer.
5700	This mountain range is incredibly beautiful.	This is a model of a mountain region.
5910	This firework was the culmination of a huge festival.	This image was generated on the computer.
7501	LasVegas has very exciting night life.	The shops in this town have long open hours.
7502	These people have a lot of fun at an amusement park.	These people are waiting to be let into the castle.
8030	This ski jumper won the first prize.	This ski jumper was placed in the middle.
8034	This woman is going to win a gold medal.	This woman won't win any gold medal.
8040	This is an athlete who has won 5 gold medals in her career life.	This is an athlete who has not attended any international competition.
8080	This catamaran driver is enjoying the sailing adventure.	This catamaran driver is fatigued by the strenuous exercise.
8090	This woman will win the golden medal because of her excellent performance.	This woman is not performing very well during this competition.
8116	This is a thrilling game between two famous rugby teams.	This is only a friendship rugby game.
8117	This man succeeded in catching the puck.	The man fell down to the floor.
8161	This man is an excellent hang glider.	This kite flier is a model hanging in a museum.

8170	Sailing is fun for many people.	Sailing could be boring.
8180	This cliff divers enjoy the feeling of flying	This photo montage was made for an advertisement.
8190	These skiers have a lot of fun	These skiers are planning to go back.
8200	This young man is a very cool water-skier.	This is a picture from an ad.
8210	This couple is enjoying the sun sea breeze.	The couple is learning how to sail.
8300	The pilot is reporting an exciting discovery.	This pilot is doing a routine report.
8370	This big family enjoys the water rafting fun.	This picture was designed for an ad.
8400	These athletes cooperate very well during rafting.	This is a painting of rafting.
8490	These people are very excited.	These actors pretend to be excited.
8496	These children have much fun on the water slide.	These children keep sliding down into the pool.
8502	That's more than $ 20,000.	This is a stack of counterfeit money
8500	These gold bars are incredibly valuable.	These gold bars are not real.

Appendix 2

The general demographics questionnaire

Angaben zur Person			
1. Alter	(	____Jahre	)
2. Gewicht	(	____Kg	)
3. Größe	(	____cm	)
4. Geschlecht? Männlich weiblich	(		)
5. Händigkeit? Linkshänder Rechtshänder	(		)
6. Muttersprache? deutsch andere ()	(		)
7. Tragen Sie eine Sehhilfe? ja nein	(		)
7.a) Wenn ja? Kurzsichtig weitsichtig	(		)
7.b) Ist Ihre Sehschwäche ausreichend korrigiert? ja nein	(		)
8. Ist Ihr Hörvermögen eingeschränkt? ja nein	(		)
9. Höchster bisher erreichter Schul-/Ausbildungsabschluss kein Hauptschule Mittlere Reife Abitur	(		)
Berufsausbildung	(		)
Hochschulabschluss	(		)
10. Zuletzt ausgeübter Beruf	(		)
11. Haben Sie einen Lebenspartner? ja nein	(		)
12. Familienstand: ledig verheiratet verwitwet geschieden	(		)
13. Rauchen Sie zurzeit Zigaretten? ja nein	(		)
	(		)
Wenn Sie ZUR ZEIT KEINE ZIGARETTEN RAUCHEN, beantworten Sie bitte die folgenden Fragen:	(		)
13.nr.a) Haben Sie schon einmal regelmäßig Zigaretten geraucht? Ja nein	(		)
13.nr.b1) Wenn ja, wann haben Sie aufgehört?	(		)
13.nr.b2) Wenn ja, wie lange haben Sie geraucht?	(		)
13.nr.b3) Wenn ja, wie viele Ziegartten haben Sie durchschnittlich am Tag geraucht?	(	____Zigaretten	)
13.nr.c) Wie viele Zigaretten haben Sie in Ihrem Leben insgesamt geraucht?	(	____Zigaretten	)
	(		)
Wenn Sie ZUR ZEIT ZIGARETTEN RAUCHEN, beantworten Sie bitte die folgenden Fragen:	(		)
13.r.a) Seit wie vielen Jahren rauchen Sie?	(	____Jahre	)
13.r.b) Wie viele Zigaretten rauchen Sie durchschnittlich am Tag?	(	____Zigaretten	)
13.r.c) Haben Sie schon einmal versucht, mit dem Rauchen aufzuhören? Ja nein	(		)
13.r.d) Wenn ja, wie oft?	(	____mal	)
13.r.e) Haben Sie vor, in den nächsten 6 Monaten aufzuhören? Ja nein	(		)
13.r.f) Haben Sie vor, in den nächsten 30 Tagen aufzuhören? Ja nein	(		)
13.r.g) Haben Sie in den vergangenen 12 Monaten für einen Tag oder länger nicht geraucht mit der Absicht, das Rauchen aufzuhören?	(		)
13.r.h) Wann haben Sie zuletzt geraucht?	(		)
13.r.i) Halten Sie sich für nikotinabhängig? Ja nein	(		)
	(		)
14. Konsumieren Sie andere Tabakprodukte? Ja nein	(		)
14.a) Wenn ja, was rauchen Sie? Zigarren/Zigarillos Pfeife Wasserpfeife Sonstiges ()	(		)
14.b) Wenn ja, wie oft rauchen Sie?	(		)
14.c) Wenn ja, wann haben Sie zuletzt geraucht?	(		)
	(		)
15. Trinken Sie Alkohol? Ja nein	(		)
15.a) Wenn ja, wann haben Sie zuletzt Alkohol getrunken?	(		)
	(		)
16. Nehmen Sie Medikamente? Ja nein	(		)
16.a) Wenn ja, welche?	(		)
16.b) Wenn ja, wann zuletzt?	(		)
	(		)
17. Haben Sie schon einmal illegale Drogen konsumiert? Ja nein	(		)
17.a) Wenn ja, welche?	(		)
17.b) Wenn ja, wann zuletzt?	(		)
	(		)
18. Wann haben Sie zuletzt etwas gegessen?	(	____Stunden	)

Fagerström Test for Nicotine Dependence (FTND)

Rauchen Sie zurzeit? Ja Nein	( )
Falls Sie zurzeit nicht rauchen, haben Sie schon einmal geraucht? Ja Nein	( )
Wenn ja, wie lange und wann haben Sie aufgehört?	(__Jahre, __Jahre)
Falls Sie zurzeit rauchen, seit wie vielen Jahren rauchen Sie?	(______ Jahre)
Haben Sie schon einmal versucht, mit dem Rauchen aufzuhören? Ja Nein	( )
Wenn ja, wie oft?	( )
Wann haben Sie zuletzt geraucht?	( )
Halten Sie sich für nikotinabhängig? Ja Nein	( )
1. Wie viele Zigaretten rauchen Sie durchschnittlich am Tag? <=10 11-15 16-20 21-25 26-30 >30	( )
2. Welche Marke rauchen Sie überwiegend? light/ultra medium	( )
Nikotingehalt: ___ ( ) Selbstgedrehte	( )
3. Inhalieren Sie beim Rauchen? Ja manchmal Nein	( )
4. Rauchen Sie am Morgen im Allgemeinen mehr als am Rest des Tages? Ja Nein	( )
5. Wann nach dem Aufwachen rauchen Sie Ihre erste Zigarette?	( )
innerhalb von 5 min 6 bis 30min 31 bis 60 min nach 60 min	
6. Auf welche Zigarette würden Sie nicht verzichten wollen? die Erste am Morgen andere	( )
7. Finden Sie es schwierig, an Orten, wo das Rauchen verboten ist (z.B. Kirche, Kino, Bücherei, usw.)	( )
das Rauchen zu unterlassen? Ja Nein	
8. Kommt es vor, dass Sie rauchen, wenn Sie den größten Teil des Tages wegen Krankheit im Bett verbringen müssen? Ja Nein	( )

The German version of the State Trait Anxiety Inventory questionnaire (STAI)

Im folgenden Fragebogen finden Sie eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann.
Bitte lesen Sie jede Feststellung durch und wählen Sie aus den vier Antworten diejenige aus, die angibt, wie Sie sich jetzt, d. h. in diesem Augenblick fühlen.
Bitte beantworten Sie die Fragen, indem Sie folgende Antwortmöglichkeiten benutzen. Es gibt keine richtigen oder falschen Antworten.
Überlegen Sie bitte nicht lange und denken sie daran, diejenige Antwort auszuwählen, die Ihren augenblicklichen Gefühlszustand am besten beschreibt.

1---------------------------2---------------------------3---------------------------4

überhaupt nicht Ein wenig ziemlich sehr

	Ihre Antwort
1. Ich bin ruhig	( )
2. Ich fühle mich geborgen	( )
3. Ich fühle mich angespannt	( )
4. Ich bin bekümmert	( )
5. Ich bin gelöst	( )
6. Ich bin aufgeregt	( )
7. Ich bin besorgt, dass etwas schief gehen könnte	( )
8. Ich fühle mich ausgeruht	( )
9. Ich bin beunruhigt	( )
10. Ich fühle mich wohl	( )
11. Ich fühle mich selbstsicher	( )
12. Ich bin nervös	( )
13. Ich bin zappelig	( )
14. Ich bin verkrampft	( )
15. Ich bin entspannt	( )
16. Ich bin zufrieden	( )
17. Ich bin besorgt	( )
18. Ich bin überreizt	( )
19. Ich bin froh	( )
20. Ich bin vergnügt	( )

The German version of the Beck Depression Inventory questionnaire (BDI)

Bitte lesen Sie jede Gruppe sorgfältig durch.	
Wählen Sie dann die eine Aussage jeder Gruppe an, die am besten beschreibt, wie Sie sich in dieser Woche einschließlich heute gefühlt haben!	
Falls mehrere Aussagen für Sie gleichermaßen zutreffen, können Sie auch mehr als eine Antwort wählen.	
Lesen Sie auf je-den Fall alle Aussagen in jeder Gruppe, bevor Sie Ihre Wahl treffen.	
	Ihre Antwort
A	( )
0. Ich fühle mich nicht traurig.	
1. Ich fühle mich traurig.	
2. Ich bin die ganze Zeit traurig und komme nicht davon los.	
3. Ich bin so traurig oder unglücklich, dass ich es kaum noch ertrage.	
B	( )
0. Ich sehe nicht besonders mutlos in die Zukunft.	
1. Ich sehe mutlos in die Zukunft	
2. Ich habe nichts, worauf ich mich freuen kann.	
3. Ich habe das Gefühl, dass die Zukunft hoffnungslos ist, und dass die Situation nicht besser werden kann.	
C	( )
0. Ich fühle mich nicht als Versager.	
1. Ich habe das Gefühl, öfter zu versagt zu haben als der Durchschnitt.	
2. Wenn ich auf mein Leben zurückblicke, sehe ich bloß eine Menge Fehlschläge.	
3. Ich habe das Gefühl, als Mensch ein völliger Versager zu sein.	
D	( )
0. Ich kann die Dinge genauso genießen wie früher.	
1. Ich kann die Dinge nicht mehr so genießen wie früher.	
2. Ich kann aus nichts mehr eine echte Befriedigung mehr ziehen.	
3. Ich bin mit allem unzufrieden oder gelangweilt.	
E	( )
0. Ich habe keine Schuldgefühle.	
1. Ich habe häufig Schuldgefühle.	
2. Ich habe fast immer Schuldgefühle.	
3. Ich habe immer Schuldgefühle.	
F	( )
0. Ich habe nicht das Gefühl, gestraft zu sein.	
1. Ich habe das Gefühl, vielleicht bestraft zu sein.	
2. Ich erwarte, bestraft zu werden.	
3. Ich habe das Gefühl, bestraft zu gehören.	
G	( )
0. Ich bin nicht von mir enttäuscht.	
1. Ich bin von mir enttäuscht.	
2. Ich finde mich fürchterlich.	
3. Ich hasse mich.	
H	( )
0. Ich habe nicht das Gefühl, schlechter zu sein als alle anderen.	
1. Ich kritisiere mich wegen meiner Fehler oder Schwächen.	
2. Ich mache mir die ganze Zeit Vorwürfe wegen meiner Mängel.	
3. Ich gebe mir für alles die Schuld was schief geht.	
I	( )
0. Ich denke nicht daran, mir etwas anzutun.	
1. Ich denke manchmal an Selbstmord, ich würde es aber nicht tun.	
2. Ich möchte mich am liebsten umbringen.	
3. Ich würde mich umbringen, wenn ich es könnte.	
J	( )
0. Ich weine nicht öfter als früher.	
1. Ich weine jetzt mehr als früher.	
2. Ich weine jetzt die ganze Zeit.	
3. Früher konnte ich weinen, aber jetzt kann ich es nicht mehr, obwohl ich es möchte.	
K	( )
0. Ich bin nicht reizbarer als sonst.	
1. Ich bin jetzt leichter verärgert oder gereizt als früher.	
2. Ich fühle mich dauernd gereizt.	
3. Die Dinge die mich früher geärgert haben, berühren mich nicht mehr.	
L	( )
0. Ich habe nicht das Interesse an anderen Menschen verloren.	
1. Ich interessiere mich jetzt weniger für andere Menschen als früher.	
2. Ich habe mein Interesse an anderen Menschen zum größten Teil verloren.	
3. Ich habe mein ganzes Interesse an anderen Menschen verloren.	
M	( )
0. Ich bin so entschlussfreudig wie immer.	
1. Ich schiebe jetzt Entscheidungen öfter als früher auf.	
2. Es fällt mir jetzt schwerer als früher, Entscheidungen zu treffen.	
3. Ich kann überhaupt keine Entscheidungen mehr treffen.	
N	( )
Ich habe nicht das Gefühl schlechter aus-zusehen als früher.	
Ich mache mir Sorgen, dass ich alt oder unattraktiv aussehe.	
Ich habe das Gefühl, dass in meinem Aus-sehen Veränderungen eingetreten sind, die mich unattraktiv machen.	
Ich finde mich hässlich.	
O	( )
0. Ich kann genauso gut arbeiten wie früher.	
1. Ich muss mir einen Ruck geben, bevor ich eine Tätigkeit in Angriff nehme.	
2. Ich muss mich zu jeder Tätigkeit zwingen.	
3. Ich bin unfähig zu arbeiten.	
P	( )
0. Ich schlafe so gut wie sonst.	
1. Ich schlafe nicht mehr so gut wie früher.	
2. Ich wache 1 bis 2 Stunden früher auf als sonst, und es fällt mir schwer wieder einzuschlafen.	
3. Ich wache mehrere Stunden früher auf als sonst und kann nicht mehr einschlafen.	
Q	( )
0. Ich ermüde nicht stärker als sonst.	
1. Ich ermüde schneller als früher.	
2. Fast alles ermüdet mich.	
3. Ich bin zu müde um etwas zu tun.	
R	( )
0. Mein Appetit ist nicht schlechter als sonst.	
1. Mein Appetit ist nicht mehr so gut wie früher.	
2. Mein Appetit hat sehr stark nachgelassen.	
3. Ich habe überhaupt keinen Appetit mehr.	
S	( )
0. Ich habe in letzter Zeit kaum abgenommen.	
1. Ich habe mehr als zwei Kilo abgenommen.	
2. Ich habe mehr als fünf Kilo abgenommen.	
3. Ich habe mehr als acht Kilo abgenommen.	
Ich esse absichtlich weniger, um abzunehmen: ja nein	( )
T	( )
0. Ich mache mir keine größeren Sorgen um meine Gesundheit als sonst.	
1. Ich mache mir Sorgen über körperliche Probleme, wie Schmerzen, Magenbe-schwerden oder Verstopfung.	
2. Ich mache mir so große Sorgen über gesundheitliche Probleme, dass es mir schwer fällt, an etwas anderes zu denken.	
3. Ich mache mir so große Sorgen über meine gesundheitlichen Probleme, dass ich an nichts anderes denken kann.	
U	( )
0. Ich habe in letzter Zeit keine Veränderung meines Interesses an Sexualität bemerkt.	
1. Ich interessiere mich jetzt weniger für Sexualität als früher.	
2. Ich interessiere mich jetzt viel weniger für Sexualität.	
3. Ich habe das Interesse für Sexualität völlig verloren.	

The German version of the Emotion Regulation questionnaire (ERQ)

Wir möchten Ihnen gerne einige Fragen zu Ihren Gefühlen stellen. Uns interessiert, wie Sie Ihre Gefühle unter Kontrolle halten, bzw. regulieren.
Zwei Aspekte Ihrer Gefühle interessieren uns dabei besonders. Einerseits ist dies Ihr emotionales Erleben, also was Sie innen fühlen.
Andererseits geht es um den emotionalen Ausdruck, also wie Sie Ihre Gefühle verbal, gestisch oder im Verhalten nach außen zeigen.
Obwohl manche der Fragen ziemlich ähnlich klingeln, unterscheiden sie sich in wesentlichen Punkten.
Bitte beantworten Sie die Fragen, indem Sie folgende Antwortmöglichkeiten benutzen.

1--------------2--------------3--------------4--------------5--------------6--------------7

stimmt überhaupt nicht	neutral	stimmt vollkommen

	Ihre Antwort
1. Wenn ich mehr positive Gefühle (wie Freude oder Heiterkeit) empfinden möchte, ändere ich, woran ich denke.	( )
2. Ich behalte meine Gefühle für mich.	( )
3. Wenn ich weniger negative Gefühle (wie Traurigkeit oder Ärger) empfinden möchte, ändere ich, woran ich denke.	( )
4. Wenn ich positive Gefühle empfinde, bemühe ich mich, sie nicht nach außen zu zeigen.	( )
5. Wenn ich in eine stressige Situation gerate, ändere ich meine Gedanken über die Situation so, dass es mich beruhigt.	( )
6. Ich halte meine Gefühle unter Kontrolle, indem ich sie nicht nach außen zeige.	( )
7. Wenn ich mehr positive Gefühle empfinden möchte, versuche ich über die Situation anders zu denken.	( )
8. Ich halte meine Gefühle unter Kontrolle, indem ich über meine aktuelle Situation anders nachdenke.	( )
9. Wenn ich negative Gefühle empfinde, sorge ich dafür, sie nicht nach außen zu zeigen.	( )
10. Wenn ich weniger negative Gefühle empfinden möchte, versuche ich über die Situation anders zu denken.	( )

Appendix 3

Experiment 2. The mean and standard error of self-ratings, facial EMG activities and LPP activities under each of the three emotion-congruent conditions by the NS group, NDS group, and the DS group

	Condition	Valence		Arousal		Craving	
		M	SE	M	SE	M	SE
NS	negative-negative	6,778	0,227	4,982	0,365	1,038	0,352
	positive-positive	3,318	0,156	3,429	0,308	1,033	0,334
	neutral-neutral	4,605	0,127	2,46	0,29	1,016	0,33
NDS	negative-negative	6,804	0,245	5,291	0,393	5,069	0,379
	positive-positive	3,297	0,168	4,015	0,331	4,484	0,359
	neutral-neutral	4,6	0,137	2,96	0,312	4,598	0,355
DS	negative-negative	6,901	0,245	6,015	0,393	5,171	0,379
	positive-positive	3,257	0,168	3,992	0,331	4,84	0,359
	neutral-neutral	4,644	0,137	3,312	0,312	4,954	0,355

	Condition	Corrugator activity		Zygomaticus activity		LPP activity	
		M	SE	M	SE	M	SE
NS	negative-negative	0,288	0,179	-0,018	0,041	10,944	1,814
	positive-positive	-0,216	0,117	0,241	0,121	7,4	1,945
	neutral-neutral	0,033	0,091	0,1	0,074	5,747	2,028
NDS	negative-negative	0,443	0,193	-0,029	0,044	12,556	1,952
	positive-positive	-0,255	0,126	0,328	0,131	8,467	2,093
	neutral-neutral	0,075	0,098	0,149	0,079	3,994	2,182
DS	negative-negative	0,311	0,193	0,014	0,044	9,841	1,952
	positive-positive	-0,342	0,126	0,195	0,131	9,554	2,093
	neutral-neutral	-0,027	0,098	0,038	0,079	7,336	2,182

Appendix 4

Experiment 3. The mean and standard error of self-ratings, facial EMG activities and LPP activities under each of the three emotion-congruent conditions by the NS group, NDS group, and the DS group

Condition		Valence		Arousal		Craving	
		M	SE	M	SE	M	SE
NS	negative-negative	6,917	0,161	5,576	0,26	1,002	0,323
	positive-positive	3,318	0,148	4,784	0,311	1,028	0,296
	neutral-neutral	4,81	0,083	2,87	0,284	1,021	0,309
NDS	negative-negative	6,738	0,164	5,592	0,265	4,359	0,33
	positive-positive	3,365	0,152	4,285	0,318	4,144	0,303
	neutral-neutral	4,616	0,084	3,339	0,29	4,329	0,316
DS	negative-negative	6,778	0,172	5,727	0,278	3,921	0,346
	positive-positive	3,479	0,159	4,539	0,334	3,783	0,318
	neutral-neutral	4,742	0,089	2,956	0,305	4,146	0,331
Condition		Corrugator activity		Zygomaticus activity		LPP activity	
		M	SE	M	SE	M	SE
NS	negative-negative	0,412	0,172	-0,06	0,051	10,568	1,595
	positive-positive	-0,228	0,086	0,168	0,115	9,539	2,828
	neutral-neutral	-0,057	0,063	0,019	0,043	10,564	2,288
NDS	negative-negative	0,535	0,175	0,023	0,052	8,423	1,631
	positive-positive	-0,35	0,088	0,4	0,118	7,345	2,891
	neutral-neutral	0,035	0,064	0,092	0,044	5,708	2,339
DS	negative-negative	0,299	0,184	0,023	0,055	13,793	1,71
	positive-positive	-0,312	0,092	0,501	0,124	11,309	3,032
	neutral-neutral	-0,005	0,067	-0,002	0,047	5,791	2,453

CURRICULUM VITAE

PERSONAL DATA

Name: Lingdan Wu

Gender: Female

EDUCATION

Since 2010 Dept. of Psycholgy I, University of Würzburg, Germany

Doctoral student studying emotion regulation in drug addiction

August 2010 Swiss center for affective sciences, University of Geneva, Switzerland

International summer school in affective sciences

2008- 2009 Dept. of Psychology, University of Arizona, USA

Training program in the field of psychophysiology

2003- 2006 Southwest University, Chongqing, PRC

MA in Psychology, awarded 13 June 2006

1999- 2003 Southwest Normal University, Chongqing, PRC

BA in Educational Technology, awarded 30 June 2003

WORK EXPERIENCE

August 2008 City University of Hong Kong, Hong Kong, PRC

Research assistant in the Dept. of Information Systems

2007 -2008 Southwest University, Chongqing, PRC

Lecture in the School of Psychology

Lab Manager in Key Lab of Cognition and Personality, MOE

2006 -2007 Southwest University, Chongqing, PRC

Assistant Teacher in the School of Psychology

Lab Manager in Key Lab of Cognition and Personality, MOE

ACADEMIC RESEARCH

2008- 2009 Chinese Scholarship Committee Award

The relationship between cardiac vagal tone and the recovery speed from stressor

August 2008 City University of Hong Kong Summer Employment Award

A joint research project on the topic: 'the problem-based learning in kindergarten education'

2006- 2008 Young Scholars Research Grant, the National Key Discipline Foundation, SWU

Emotion recognition from facial expressions- an Eye-Movement study

2004- 2005 Took active part in a key project funded by the NKDF, SWU

Spatial cognition in immersive virtual environment

2003- 2005 Took active part in the 15th key project funded by Ministry of Education of China

Children's use of learning strategies in simple arithmetic problems

Presentations

(1) Wu, L. D., Wieser, M. J., Winkler, M. H., Andreatta, M., & Pauli, P. (May 2012). The contingent negative variation predicts the effect of appraisal frames on the late positive potential. Poster presentation on the 1th Conference of the European Society for Cognitive and Affective Neuroscience (ESCAN2012), Marseille, France.
(2) Wu, L. D., Winkler, M. H., Andreatta, M., & Pauli, P. (Sep 2011). Cognitive Reappraisal of Positive and Negative Pictures Alters Emotional Responses as Reflected in Self-Report and Facial Electromyographic Activity. Poster presentation on the 51th Annual Meeting of the Society for Psychophysiological Research, Boston, Massachusetts, America. [Abstract]. Psychophysiology, 48, S101-S101.
(3) Wu, L. D., Pu, J., Marta, A., Pauli, P., & Allen, J. J. B. (Sep 2010). Asymmetric Eye Movements during Facial Emotion Recognition in Individuals with Elevated Levels of Depressive Symptoms. Poster presentation on the 50th Annual Meeting of the Society for Psychophysiological Research, Portland, Oregon, America. [Abstract]. Psychophysiology, 47, S70-S70.
(4) Pu, J., Wu, L. D., & Allen, J. J. B. (Sep 2009). Cardiac Vagal Control and Depression: The Moderating Effect of Sex. Poster presentation on the 49th Annual Meeting of the Society for Psychophysiological Research, Berlin, Germany. [Abstract]. Psychophysiology, 46, S80-S80.
(5) Wu, L.D., Zhao, G., Ouyang, L., Lei, W.T. & Zhang, M.L. (Jun 2008). Recognition accuracy and visual scanning of emotional faces in individuals with depressive disorder. Oral presented at the 3rd Annual China International Conference on Eye Movement Studies, Zhuhai, China.
(6) Zhao, H.-Y., Wang, P., Jiang, A.-S., Wu, L.-D., & Sun, H.-J. (May 2008). Estimation of distance on flat and uphill terrains using visual matching and blind walking task. Poster presented at the Annual Meeting of the Vision Sciences Society. Florida, America. [Abstract]. Journal of Vision, 8(6):752, 752a, http://journalofvision.org/8/6/752/, doi:10.1167/ 86752
(7) Wu, L.D., Zhao, H.Y., Liu, Q., Campos, J.L. & Sun, H.J. (May 2006). Estimating distance and duration of travel: A possible shared mechanism. Poster presented at the Annual Meeting of the Vision Sciences Society. Florida, America. [Abstract]. Journal of Vision, 6(6):146, 146a, http://journalofvision.org/6/6/146/, doi: 10.116 7/ 6.6.146.
(8) Wu, L.D., Liu, D.Z. (Jun 2005). Young Children's pattern of strategy choices in simple arithmetic problems (Chinese). Poster presentation at the 5th Chinese Psychologist Conference, Suzhou, China.
(9) Wu, L.D., Liu, D.Z. (Oct 2004). Analysis of cognitive bias in web-based human-human interaction. Oral presented at the 28th International Conference of Psychology, Beijing, China. [Abstract]. International Journal of Psychology, 39 (5-6): 442-442 Suppl. S, Oct-Dec.

Papers/ Manuscripts

(1) Wu, L.D., Wieser, M. J., Winkler, M. H., Andreatta, M., & Pauli, P. Effects of smoking advertisements, neutral smoking scenes and anti-smoking advertisements on subjective experience and psychophysiological responses (in preparation)
(2) Wu, L.D., Schulz, S. M., & Pauli, P. Liking and wanting of drug rewards and non-drug rewards in heavy smokers (in preparation)
(3) Wu, L.D., Wieser, M. J., Winkler, M. H., Andreatta, M., & Pauli, P. The contingent negative variation predicts the effect of appraisal frames on the late positive potential (in preparation)
(4) Wu, L.D., Winkler, M. H., Andreatta, M., Hajcak, G., & Pauli, P. (2012). Appraisal frames of pleasant and unpleasant pictures alter emotional responses as reflected in self-report and facial electromyographic activity. International Journal of Psychophysiology, 85(2), 224-229. doi: http://dx.doi.org/10.1016/j.ijpsycho.2012.04.010
(5) Wu, L.D., Pu, J., Allen, J. J., & Pauli, P. (2012). Recognition of facial expressions in individuals with elevated levels of depressive symptoms: an eye-movement study. Depress Res Treat, 2012, 249030. doi: 10.1155/2012/249030
(6) Yan, J.J., Wu, L.D., Sun, H.J. (2007). A review on virtual reality exposure therapy for fear of flying. Progress in Modern Biomedicine (Chinese), 9, 1372-1375
(7) Wu, L.D., Liu, D.Z. (2006) Children's meta-cognitive monitoring and strategy selection during counting. Psychological Science (Chinese), 29, 354~357
(8) Tao, W.D., Sun, H.J, Tao, X.L., Liu, Q., Wu, L.D., Luo, W.B. (2006). Application of immersed virtual reality technology in psychological research. Progress in Modern Biomedicine (Chinese), 6(3), 58~62
(9) Wu, L.D., Liu, D.Z. (2005) Analysis of psychological factors of pathological internet use. International Chinese Application Psychology Journal, 2, 212~215
(10) Wu, L.D., Liu, D.Z. (2005) Phases of teaching learning strategies & diversity in teaching methods. Education Today (Chinese), 7, 30-32

SELECTED AWARDS AND HONORS

Jan 2013. Best Publication Award, 2012, GK-emotions, University of Wuerzburg, Germany.

Jun 2006. Outstanding Master's Thesis Award, Chongqing Municipal Government, China

Oct 2004. Graduate Student Excellence Award, Southwest Normal University, China

Oct 2002. Third Prize of the 6th National Competition of Multimedia Educational Software Development, National Center for Educational Technology, China