University of Alberta

Attention and Memory in Repressive Coping Style

by

Lauren Leanne Alston

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of requirements for degree of

Master of Science

Centre for Neuroscience

Spring 2014
Edmonton, Alberta

Abstract

People with a repressive stress coping style have high levels of unacknowledged anxiety. Repressors are thought to show attentional vigilance-avoidance patterns towards threat information, followed by memory reductions. The direct relationships between attention and memory for threat in repressive coping were tested here. Participants (N=107) were subjected to a stress-task. Skin conductance levels and self-reported mood were combined into an ‘autonomic-response discrepancy (ARD) score indicating under-reported physiological stress (repressive coping). Negative and neutral pictures were presented with or without distractors while eye-tracking was recorded, followed by recall/recognition tests. ARD correlated positively with viewing time of all pictures. ARD decreased the memory advantage for negative solitary compared to neutral pictures. For these pictures only, the link between attention and memory increased with increasing ARD. This suggests when attentional avoidance is not possible, repressive coping may co-vary with stronger reliance on visual attention to aid later memory for threat.

Acknowledgement

I began my master’s degree relatively naïve to what it entails. I understood the aspect of coursework, developing a research project, and analyzing the results, but what I have come to learn is the immense amount of trial and error a thesis project requires. With each trial I gained experience and with each error I gained knowledge, a process which could have not been possible without the help of many important people who assisted in providing feedback, direction, advice, and new perspectives. There are many people I would like to thank who contributed in their own way to making my degree the rewarding and educational experience it was.

Thank you, Dr. Esther Fujiwara, for being an exceptional supervisor and mentor throughout my graduate degree. Together we developed a research project that I am very proud of: from hardware, to software, to experimental design and analysis. You provided me with the opportunity to explore technologically advanced methods of behavioural and physiological measurement as well as designing my own experimental paradigm. Not only did you provide me with a plethora of resources, but also an abundance of helpful critiques and support. I am very appreciative of the time and effort that you dedicated to ensuring I produce quality research. Your guidance and knowledge have been invaluable to me and have been essential aspects of my learning experience. I am grateful for the opportunity you provided me and for the resulting acquired skills that I can apply to my forthcoming endeavours. You have been essential to my development as a researcher, student, critical thinker, and significantly augmented the skills I need to achieve my future aspirations.

Thank you, Dr. Anthony Singhal, for providing me with many helpful resources during my degree. From the reading course to the rotation in your lab, you have played a key role in the expansion of my knowledge outside of my area of research. I am grateful to have gained experience in electroencephalography, experimental design, and research presentation skills. I valued your insight on a variety of areas in addition to the encouraging and considerate manner in which you communicated it.

Thank you, Dr. Takahiko Masuda, for taking the time to meet and discuss my thesis despite being on sabbatical half-way around the world. Your intuition and perspective were very valuable to the development and progress of my research.

Thank you, Dr. Sandra Wiebe, for enlightening me on new methods in which I can approach my data analysis and for your contribution to the production of my thesis.

Thank you, Megan Airmet and Tara Checknita, for welcoming my copious questions and ensuring that I have everything I need in order to succeed in my degree. Your dedication to looking out for my best interest created a very positive graduate experience.

Thank you, Nathan Bartlett, for your extremely diligent approach to data collection, your insightful perspectives on research methods and their psychological applications, as well as the countless hours you dedicated to helping me acquire and analyze my thesis data. You have played an extremely important and positive role in both my academic and personal life.

Thank you, Jonn Kmech, for all of your help with meticulously editing my thesis document and presentation. I am very grateful for your continuous and selfless help throughout my degree.

Thank you to my funding sources who made my graduate work possible; the Social Sciences and Humanities Research Council, the Centre for Neuroscience, the Faculty of Graduate Studies and Research, and the Graduate Students' Association.

Thank you to my family for being an unlimited source of love and encouragement. Thank you to my grandparents, aunts, uncles, and cousins who have been continuous sources of reinforcement and positivity. Thank you to my parents, Jan and Lossie, you both have provided me with an incredible foundation from which I am able to continuously build upon, and you have blessed me with support, encouragement, and understanding throughout my academic endeavors. Thank you to my sister Vanessa, your incredible achievements, hard work ethic and sincere kindness are exceptionally inspiring. Thank you to my brother Reid, for engaging me in thought-provoking discussions and enlightening me with your knowledge and perspective. Thank you to my sister Mariana, for providing me with an abundance of support, laughs, and always lifting my spirits.

Thank you to my friends both outside of my academic life and within the halls of RTF and Biosci. You have all played essential roles throughout my development as a graduate student and as a person. I am so grateful to have ventured through my graduate degree with you cheering me on the entire way.

Table of Contents

Section Page

List of Tables

Table Page

List of Figures

Figure Page

List of Abbreviations

ARD	Autonomic-response discrepancy
AARD	Affective-autonomic response discrepancy
BIDR	Balanced Inventory of Desirable Responding
BOLD	Blood oxygen level-dependent
BLA	Basolateral amygdala
d’	d-prime
DHA	Defensive High-Anxious (high-anxious, high-defensive)
DM	Difference due to memory
EDA	Electrodermal activity
EEG	Electroencephalography
EEM	Emotional enhancement of memory
Enc	Encoding
ERP	Event-related potential
F	False alarms rate
fMRI	Functional magnetic resonance imaging
FR	Free recall
H	Hit rate
HA	High-anxious (high-anxious, low-defensive)
Hz	Hertz
IAPS	International Affective Picture System
ISE	Index of Self-Regulation Emotion
LA	Low-Anxious (low-anxious, low-defensive)
MC-SDS	Marlowe-Crowne Social Desirability Scale
MCI-R	Mainz Coping Inventory-Revised
M	Mean
Md	Median
Msec	Milliseconds
N	Number of participants

NE	Norepinephrine
Neg	Negative
Neu	Neutral
REP	Repressors (low-anxious, high defensive)
Recog	Recognition
Rg	Range
SAM	Self-Assessment Manikins
SCL	Skin conductance level
SD	Standard deviation
SDE	Self-deceptive enhancement
SME	Subsequent memory effect
STAI	State-Trait-Anxiety Inventory
STAI-T	Trait version of the State-Trait Anxiety Inventory
TMAS	Taylor Manifest Anxiety Scale
TSST	Trier Social Stress Test
VAS	Visual analogue scale
VD	Viewing duration

1. INTRODUCTION

Stress coping is an important cornerstone of mental health and included in virtually all psychological therapies. When encountering threatening, negative, or otherwise stressful situations, stress coping is commonly understood as a psychological mechanism targeted at managing the emotional impact of the stressor. Stress coping varies as a function of personality, past experiences, and current environment, and can be both a cause and effect of cognitive changes. The objective of this thesis is to investigate how individual differences in a so-called repressive coping style influence attention and memory for negative emotional information, as well as the link between the two. A short overview on known effects of emotion on attention, memory and their link, irrespective of coping style, is provided in the beginning of the introduction. The next section outlines the measurement of repressive coping style. The introduction closes with an overview on cognitive characteristics of the repressive coping style.

1.1 Emotion-Cognition Interactions

The following information is provided as a non-exhaustive review on literature pertaining to emotion-cognition interactions. It is to be understood as a brief overview on experimental parameters that were expected to operate in a principled way based on extensive basic research in emotion-cognition interactions, irrespective of stress coping style.

Studying emotion-cognition interactions in a laboratory setting can be achieved in various ways, but two main approaches are a) inducing emotion in the participants and studying the resulting effects on cognition, and b) selecting materials based on their pre-existing emotional features and studying altered cognitive processes towards emotional compared to neutral materials. These two approaches are also sometimes combined. Inducing emotions in the laboratory is difficult but often approached by stress induction paradigms.

1.1.1 Stress and Cognition

One of the earliest observations on the relationship between stress and cognition, the Yerkes-Dodson law (Yerkes & Dodson, 1908), was that low or high stress levels may impair cognitive functions while intermediate levels may benefit cognition. For ethical reasons, stress induction paradigms in humans are confined to relatively mild manipulations; for example, physical stressors like minor electrical shocks and heat/cold stress, or psychosocial stress manipulations such as the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), part of which was used in the current study. In the TSST, participants are asked to perform a difficult mental arithmetic task and to deliver a speech in front of a panel of judges. This paradigm reliably increases the stress hormone cortisol and leads to subsequent changes in cognition, including memory, executive functions, and attention (Brune, Nadolny, Gunturkun, & Wolf, 2013; Ellenbogen, Carson, & Pishva, 2010; Plessow, Kiesel, & Kirschbaum, 2012; Plessow, Schade, Kirschbaum, & Fischer, 2012; Roelofs, Bakvis, Hermans, van Pelt, & van Honk, 2007; Simoens et al., 2007; Wolf, 2011).

With regard to attention, stress reduces cue utilization, shrinks the perceptive field, or reduces an individual's ability to perform broad visual scans of the environment. Thus, under stress, selective attention becomes focused on task-relevant information at the expense of task-irrelevant information (Chajut & Algom, 2003), the so-called 'tunnel hypothesis' (Easterbrook, 1959). Whether attention functions benefit or suffer under stress largely depends on the type of task and stimuli. For example, Chajut and Algom (2003) found that different stressors (noise, difficult or impossible tasks) were *beneficial* to selective attention tasks measured with the Stroop task, in agreement with the tunnel hypothesis. Thus, participants' ability to focus on the task at hand, i.e., naming the ink colour in which colour words with an incongruent meaning were written and to ignore irrelevant aspects of the task, i.e., the meaning of the colour words, increased under stress. Combining stress induction with attention to *emotional* information, several studies have shown that stress-induced cortisol levels will bias selective attention towards emotional stimuli (Applehans & Luecken, 2006;

Ellenbogen et al., 2010; Ellenbogen, Schwartzman, Stewart, & Walker, 2002; McHugh, Behar, Gutner, Geem, & Otto, 2010 ; Pilgrim, Marin, & Lupien, 2010; van Honk et al., 2000). That is, when stressed, a normative pattern of attentional preference of emotional over neutral stimuli can become exaggerated.

Similarly, stress can be detrimental or beneficial to memory. For example, low or high stress levels can be memory-impairing while intermediate levels can be beneficial to memory (Cavanagh, Frank, & Allen, 2011; Sandi & Pinelo-Nava, 2007). Specific effects of stress on memory are dependent on the materials and the type of memory tested. There is support for stress-enhancement of (emotional) memory encoding and consolidation (Beckner, Tucker, Delville, & Mohr, 2006; Cahill & Alkire, 2003; Jelici, Geraerts, Merckelbach, & Guerrieri, 2004; Smeets, Giesbrecht, Jelicic, & Merckelbach, 2007), while memory retrieval suffers under stress (e.g., de Quervain, 2006; Dominique, Roozendaal, Nitsch, McGaugh, & Hock, 2000; Kuhlmann, Piel, & Wolf, 2005). As reviewed by Wolf (2008), human and rodent studies have supported that stress-induced cortisol release is associated with enhanced memory for fearful situations. While non-emotional forms of explicit memory, mediated by the hippocampus and areas of the prefrontal cortex, become impaired under high stress, emotional learning facilitated by the amygdala is enhanced. Thus, one might observe an exaggerated preference for learning and remembering emotionally arousing information under stress similar to the above mentioned effects of stress on attention.

1.1.2 Emotion Effects on Attention and Memory

Emotional information usually engages processing priority compared to neutral information (Reisberg & Heuer, 2004). Emotionally arousing materials capture and hold greater attention than neutral information, especially when both are concurrently presented (A. K. Anderson & Phelps, 2001; M. M. Bradley & Lang, 1994; Calvo & Lang, 2005; Loftus, Loftus, & Messo, 1987). Emotionally arousing information, especially when negative, is also usually better remembered than neutral information (Cahill & McGaugh, 1998; Hamann, 2001; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Strange & Dolan, 2004). Emotional (but not neutral) information can be processed without conscious awareness (Morris, DeGelder, Weiskrantz, & Dolan, 2001; Morris, Ohman, & Dolan, 1998) and with little (or no) visual attention (Calvo & Lang, 2005; Christianson, Loftus, Hoffman, & Loftus, 1991; but see Pessoa, 2005). While these findings emphasize the prioritization of emotional over neutral information processing, the precise links between emotional arousal, attention, and memory are debated (Pessoa, 2005; Sharot & Phelps, 2004; Talmi & McGarry, 2012; see section 1.1.3).

Emotional materials for laboratory experiments are often selected based on two criteria: arousal, the quantitative level of physiological response evoked by a stimulus, and valence, the qualitative emotional content of a stimulus ranging from negative to neutral to positive (see Lang, Bradley, & Cuthbert, 1999). Highly arousing stimuli are used most commonly when studying emotional attention and emotional memory, based on arousal- (but not valence-) mediated modulation of other brain regions by the amygdala (LaBar & Cabeza, 2006; McGaugh, 2004). The amygdala has long been known as a core structure for emotional, especially fear-related information processing (LeDoux, 2000). It provides direct and indirect signals to virtually all other brain regions, and is capable of to modulating many cognitive and sensory processes (Pessoa, 2008).

Emotionally arousing materials will often alter perception and attention. Similar to the attentional narrowing by stress, emotionally arousing materials are preferentially attended to, compared to neutral information. For example, in visual search tasks where a unique target must be found among distractors, detection times are faster when the target is arousing (e.g. a snake picture or spider picture among pictures of flowers e.g., Öhman, Flykt, & Esteves, 2001). In ‘attentional blink’ paradigms, a visual target is often missed when presented shortly after another target in a continuous stream of stimuli, but such failures are reduced when the first target is emotionally arousing (A. K. Anderson, 2005), implying facilitation of attentional mechanisms by emotion. Thus, when deployment of attentional resources is limited, emotionally-arousing information may receive privileged access to attention (see also Vuilleumier & Schwartz, 2001).

An arousing stimulus or situation will trigger a cascade of neurochemical reactions. Amongst these, the release of norepinephrine will enhance glutamatergic synaptic plasticity in the basolateral amygdala and hippocampus, a process thought to underlie learning and memory functions (e.g., Kensinger, Garoff-Eaton, & Schacter, 2007; LaBar & Cabeza, 2006). Through this process, arousing materials are usually remembered better than neutral stimuli, an effect called the ‘emotional enhancement of memory’ (EEM). Amygdala-hippocampus interactions pertaining to emotional memory have been tested in many studies, usually pointing to a modulatory effect of the amygdala on hippocampal learning (review see: LaBar & Cabeza, 2006). For example, Kensinger and Corkin (2004) used highly arousing negative and non-arousing neutral words in a functional magnetic resonance imaging (fMRI) memory experiment. They found that activity in both regions at encoding was predictive of later memory of high-arousal words, while only activity in the hippocampus (and not in the amygdala) was predictive of memory for non-arousing words. Amygdala activity in addition to hippocampal activity during encoding of arousing words correlated with increased vividness of emotional word recall.

1.1.3 Linking Arousal, Attention, and Memory

One way of investigating direct links between attention and memory is the *subsequent memory effect* (also known as: difference due to memory [DM], Wagner et al., 1998). This method is often used in electroencephalographic (EEG) and fMRI studies, and compares brain activity during encoding of items that were later remembered with brain activity during encoding of items that were later forgotten (Wagner, Koutstaal, & Schacter, 1999). For example, in an EEG study, one might compare the size of a specific event-related potential (ERP) elicited during encoding of items that were later forgotten and subtract this ERP from the size of the average ERP during encoding of items that were remembered. Thus one would create a residual ERP difference wave that illustrates the difference in electrical activity between successful and unsuccessful attempts of encoding. Broadly speaking, emotional information can change the topography, extent, and size of the subsequent memory effect (Dolcos, LaBar, & Cabeza, 2004; Erk et al., 2003; Kensinger & Schacter, 2006) depending on the paradigm and stimuli used. For example, Dolcos and Cabeza (2002) found a larger subsequent memory effect at an encoding epoch from 400-600 msec for emotional compared to neutral pictures. Qualitatively different and/or enhanced subsequent memory effects for emotional than neutral information were also found in several fMRI studies (e.g., Dolcos et al., 2004; Richardson, Strange, & Dolan, 2004; Schwarze, Bingel, & Sommer, 2012). Although these examples refer to EEG and fMRI studies, the subsequent memory effect can, in principle, be calculated with any behavioural or physiological measure, including eye-tracking.

The perceptual processing of stimuli is largely (although not exclusively) attributed to visual processing; therefore, *visual* attention can be used as an indicator of perception and attention. One way to assess overt visual attention is through eye-tracking. This method can be employed to assess effects of emotion on overt[1] attention (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Nummenmaa, Hyönä, & Calvo, 2006; Wadlinger & Isaacowitz, 2006), changes in their interaction as a function of personality factors (Quigley, Nelson, Carriere, Smilek, & Purdon, 2012) and can reveal processes that are not testable by relying on manual responses alone (Berggren, Koster, & Derakshan, 2012).

Memory increases with increased attention (Baddeley, 1997) and as outlined, arousal can influence both, attention and memory. Thus, one may ask whether the enhancement of emotional memory is a purely attentional effect. Studies have tested this hypothesis with eye-tracking (Christianson et al., 1991; Loftus et al., 1987; Riggs, McQuiggan, Farb, Anderson, & Ryan, 2011; Wessel, De Kooy, & Merckelbach, 2000). In these studies, attentional preference of emotional over neutral information at encoding was probed by presenting central arousing or non-arousing information surrounded by peripheral (non-arousing) information. Subsequent memory for the central and peripheral information was tested. This type of setup was motivated by the assumed attentional narrowing

---

[1] Dissociating between covert and overt attention is better attempted by experimental paradigms that manipulate each of them separately (Theeuwes, 1991; Yantis & Jonides, 1990). In the normal case both overt and covert attention are highly correlated (Jonides, 1981).

caused by arousing stimuli (Easterbrook, 1959), to test whether increased later memory for the emotional scenes may be a necessary consequence of the narrowed attention at encoding. Viewing patterns in all three studies supported attentional prioritization in form of longer view times to (central) arousing information than (peripheral) non-arousing information. In addition, there was better memory for central negative versus neutral details. However, more attention did not uniformly result in better memory. As such, Christianson and others (1991) found that participants who spent longer viewing the central aspects of the scene did not have better recognition memory than participants with shorter view times. An increase in emotional scene view time in Riggs and others (2011) only partially, but not fully mediated an enhancement of later memory for the emotional scenes. In addition, peripheral details flanking the central emotional scenes were fixated less and remembered less, but these two effects were unrelated. Thus, negative emotionally arousing information, at least when presented centrally, will induce attentional narrowing and enhancement of later memory, but the latter may at least partly result from processes other than overt visual attention.

Another illustration of the partial independence of the EEM from attentional processes comes from Kensinger and Corkin (2004). They tested whether encoding of arousing negative words and non-arousing negative words during a divided attention task and a full attention task. Results showed a main effect of task with lower memory for words encoded under divided attention than full attention. However, divided attention impaired later retrieval of non-arousing negative words more so than recall of negative words. These findings imply that arousing information will maintain an encoding advantage over non-arousing information even when attentional resources are depleted (Kensinger & Corkin, 2004). A possible interpretation of these kinds of partial mediation effects is that arousal itself also enhances memory formation, in addition to increasing attention, such that the relative strength of attention-memory links are weakened in case of emotional materials.

If both, attention and arousal may mediate the EEM, when does one predominate over the other? Recent work by Talmi and McGarry (2012) addressed this question. Prior to this study, Talmi had observed systematic differences between emotional and non-emotional materials that may favour emotional over neutral materials for reasons other than their difference in the potential to trigger arousal. These features include higher distinctiveness of emotional items if mixed with neutral items, or a higher semantic cohesiveness among emotional than neutral materials, both of which would increase memory for emotional items but for reasons other than their arousing nature (Talmi & Moscovitch, 2004; Talmi, Schimmack, Paterson, & Moscovitch, 2007). With this in mind, Talmi and McGarry (2012) could show that the EEM can be reduced if participants are required to attend to neutral and negative pictures equally. They did not find a free recall advantage for negative arousing compared to neutral pictures in this case. In addition, attention fully mediated later memory when pictures were presented in blocks of emotional or neutral pictures (controlling for picture differences in semantic cohesiveness and distinctiveness), while perceived arousal independently increased attention and later memory when pictures were presented in mixed lists. These findings argue for a distinctiveness explanation of the EEM, rather than an arousal-mediated effect.

Taken together, the influence of emotional material on later memory is likely mediated by physiological arousal combined with attentional prioritization. Emotional arousal may enhance memory directly as well as through attentional processes. My study targets potential influences of a so-called repressive stress coping style on emotion-cognition interactions. As such, I am interested in whether and how repressive coping will influence attention and memory for emotional information as well as their links. The following sections give an overview on the repressive coping style literature with an emphasis on known cognitive correlates of this type of stress coping.

1.2 Repressive Coping Style

The term “repression” was originally coined by Sigmund Freud (Freud, 1957/1915). Although Freud’s definitions of repression varied and changed over time, including terms like “conscious rejection”, “dissociation”, “attention neglect”, and “avoidance of thought” (as discussed by Erdelyi, 2006), repression in the Freudian sense usually refers to the avoidance of thoughts, memories, impulses, and desires that are incompatible with one’s self-view (ego), with the goal to exclude these contents from consciousness. Conscious awareness of (ego-) threatening thoughts or memories would trigger anxiety, so by “repressing” them, anxiety-provoking experiences are avoided. Debated for over a century, empirical evidence for the existence of repression as a general mechanism of forgetting has been variable since early research (Flavell, 1955; Rosenzweig & Mason, 1934; Stagner, 1931).

There are several intrinsic problems with the scientific study of repression. For example, the absence of unwanted content (thoughts, memories, desires, etc.) can be evidence both for the existence of repression, as well as proof of their non-existence, rendering repression as a construct non-falsifiable. The precise definition of repression determines the level of experimental support that has been gathered for or against its existence. For example, while willful, instructed forgetting of information is possible at least to some extent (M. C. Anderson & Green, 2001; Depue, Banich, & Curran, 2006; but see Bulevich, Roediger, Balota, & Butler, 2006), there is no firm evidence for frank amnesia following psychological trauma (McNally, Clancy, & Barrett, 2004). Considering that the experience of a psychological trauma represents a highly self-threatening event, ‘repressive’ forces on memory should be most apparent in or after such extreme situations. However, memory for highly traumatic self-threatening events is usually very detailed, and even intrusive (McNally et al., 2004; Piper Jr, Pope Jr, & Borowiecki III, 2000), a finding in agreement with the EEM described above. Thus, repression as a general mechanism of forgetting unwanted memories certainly does not apply uniformly to everyone and does not co-vary with the severity of the trauma.

An alternative to the study of repression is to focus on individual - differences in dispositional repressiveness, based on measurable and stable personality traits. Conceptually linked to the psychodynamic view of ‘repression’ as a defense mechanism to deal with (ego-) threat, research into a repressive coping style gained momentum in the 1960ies (but see prior research by Altrocchi, Parsons, & Dickoff, 1960). As such, Byrne, Barry and Nelson (1963) defined repressive individuals as avoidant and defensive in the face of threat. Repressors were contrasted with so-called sensitizers, who were described as approaching threat and intellectualizing it, also as a defense mechanism. The Byrne Repression-Sensitization Scale-revised (Byrne et al., 1963) became a widely-used scale at that time. However, high scores in sensitization correlated positively with scales measuring trait anxiety (assessed with scales like the Taylor Manifest Anxiety Scale, TMAS; Taylor, [1953] or its short version by Bendig [1956]), while scores in repression correlated negatively with trait-anxiety (Abbott, 1972; Highland, 1980; Slough, Kleinknecht, & Thorndike, 1984). Thus, the Byrne Repression-Sensitization Scale equated and therefore confounded high trait-anxiety with sensitization and low trait-anxiety with repression (Slough et al., 1984).

Weinberger, Schwartz, and Davidson (1979) re-introduced scientific interest in ‘repression’ by operationalizing repressive coping as an explicit combination of trait-anxiety (Shortened Taylor Manifest Anxiety Scale: Bendig, 1956) and social desirability as a form of defensiveness (Marlowe-Crowne Social Desirability Scale [MC-SDS]: Crowne & Marlowe, [1964]). Rather than controlling for (partial) overlap between repressiveness and anxiety/social desirability, this approach explicitly required repressors to have both low trait-anxiety *and* high defensiveness. Thus, combining defensiveness and anxiety with two different questionnaires, four separate coping styles can be determined, according to Weinberger and others (1979): Repressive individuals (scoring low in trait anxiety and high in defensiveness), high-anxious individuals (high anxiety, low defensiveness), truly low-anxious individuals (low anxiety, low defensiveness), and defensive high-anxious individuals (high anxiety, high defensiveness). The authors argued that accounting for defensiveness separates the reportedly low-anxious (i.e., repressors) from the (truly) low-anxious individuals, in contrast to their confounding in Byrne’s approach. A critical related finding in this study was that their repressive group (i.e., low anxiety, high defensiveness) not only under-reported trait anxiety, but also under-reported their subjective experience of anxiety during an experimental stress task, relative to showing physiologically high levels of anxious arousal. This was not the case for the other coping style groups tested (truly low anxious individuals or high anxious individuals). That is, Weinberger and others (1979) showed evidence for the existence of unacknowledged high anxiety in some (repressors) but not all (truly low-anxious) individuals who report low trait anxiety in a questionnaire.

Whereas Weinberger and others (1979) were instrumental in introducing defensiveness as an integral part of the repressive coping style, other researchers have approached the classification of coping styles differently. Krohne (1993) proposed that ‘vigilance’ and ‘avoidance’ are two independent mechanisms to deal with stress and anxiety. Krohne’s ‘Model of Coping Modes’ (Krohne, 1986) forms the basis of the Mainz Coping Inventory – revised (R) (MCI-R; Krohne et al., 2000), the tool to measure vigilance and avoidance. Within this framework, vigilance is characterised as heightened awareness and preparatory scanning of stress-related information in the environment with an assumed underlying motivation to decrease uncertainty. Cognitive avoidance is defined as a coping strategy where an individual averts attention from threat-relevant cues, with the assumed underlying motivation to decrease arousal. The MCI-R assesses mean levels and cross-situational consistency of vigilant and avoidant stress-coping by presenting short vignettes of potentially threatening situations (e.g., “Imagine that you are riding in a car as a front-seat passenger next to an obviously inexperienced driver. Road conditions are poor due to snow and ice”) and asking for one’s most likely reaction (e.g., “I tell myself 'Thank goodness, he is not driving that fast.'“[avoidant]; “I watch the driver carefully and try to tell in advance when he is going to make a mistake” [vigilant]). The scores on the two dimensions reflect the person’s mode of coping, in four main modes: “Consistent vigilance or sensitization" (high vigilance, low avoidance); "consistent cognitive avoidance or repression" (low vigilance, high avoidance); "fluctuating coping or high anxiety" (high vigilance, high avoidance); and "situation-related coping or low anxiety" (low vigilance, low avoidance; see Krohne et al., 2000). Thus, some of Byrne's original terminology (repression – sensitization) is retained in the MCI-R, with repressors here being defined as people who consistently use cognitive avoidance behaviour to deal with stressful situations. However, it should be noted that some of the initial criticism of Byrne's classification also translates to the MCI-R; that is, avoidant (i.e., repressive) coping in the MCI-R is often negatively correlated with trait anxiety, again confounding the two constructs (Bijttebier, Vertommen, & Steene, 2001; Hock & Krohne, 2004; Paul et al., 2011). For this reason, the MCI-R was not further pursued in my thesis. Following suggestions by Weinberger and others (1979), repressive coping is defined here as:

> *Coping with a stressful situation by not acknowledging its anxiety-provoking effects in oneself.*

1.3. Measurement of the Repressive Coping Style

A problem in repressive coping style research is the lack of consistency in the choice of the various questionnaires (or combinations of questionnaires). Even among studies that used the same method, there is considerable variability in how precisely repressive coping is demarcated against other styles. For example, following Weinberger et al. (1979), many studies pre-screen a large number of potential participants prior to an experiment and choose those who fall into each coping style group based on median, tertiary splits, or quartile splits of all scores on questionnaires measuring anxiety (then categorized as 'low' or 'high') and defensiveness ('low' or 'high'), thereby omitting people with non-extreme scores (Derakshan & Eysenck, 1997; Myers & Brewin, 1994, 1996; Myers & Derakshan, 2004). The scores used as cut-offs are therefore relatively arbitrary and depend on the base sample they were derived from. Modern personality psychology, including research in personality disorders, generally advocates personality dimensions rather than distinct and stable types or categories (Trull & Durrett, 2005; Widiger & Samuel, 2005). As such, to bypass Weinberger's categorization method, Mendolia (2002) proposed the Index of Self-Regulation of Emotion (ISE), a simple linear combination of defensiveness and anxiety scale scores. The ISE treats coping style as a continuum with individuals who do *not* distance themselves from experiencing emotionally threatening events on the low end of the ISE, and individuals who do distance themselves from negative emotional experiences on the high end (Mendolia, 2002). Cross-validated against Weinberger and colleagues' (1979) typology, repressors scored highest in the ISE and high-anxious individuals scored lowest. Defensive high-anxious and low-anxious individuals were adjacent groups in the middle ISE ranges. Although the ISE offers a more realistic gradient of coping style and bypasses arbitrary grouping cut-off scores, its counterintuitive clustering of low anxious and defensive high anxious individuals next to each other (i.e., two groups that show divergent answers in both anxiety and defensiveness scales) is difficult to interpret. Furthermore, it still relies on self-reported anxiety and defensiveness. This is inherently problematic as according to Weinberger and others (1979), one of the core assumptions of the repressive coping style is that repressive individuals should be unable and/or unwilling to report their true levels of anxiety. That is, asking for self-report from individuals whose self-report is unreliable remains problematic even if including a measure of defensiveness.

Thus, to avoid solely relying on questionnaires, a discrepancy measure between self-reported and physiological levels of anxiety or stress can be used. A relatively consensual finding in a large body of research has been that repressors, compared to different groups of non-repressors, exhibit relatively low levels of reported stress in conjunction with high physiological stress responses (Asendorpf & Scherer, 1983; Brosschot & Janssen, 1998; Gudjonsson, 1981; Pauls & Stemmler, 2003; Weinberger et al., 1979). Common physiological stress measures include skin conductance level (Coifman, Bonanno, Ray, & Gross, 2007; Gudjonsson, 1981; Jorgensen & Zachariae, 2006; Pauls & Stemmler, 2003;

Weinberger et al., 1979), heart rate (Fuller, 1992; Weinberger et al., 1979), heart rate variability (Fuller, 1992; Jorgensen & Zachariae, 2006; Schwerdtfeger & Derakshan, 2010), and muscle tension (Pauls & Stemmler, 2003; Weinberger et al., 1979). Of these measures, arousal-induced skin conductance levels seem to be the most reliable indicator to successfully differentiate between repressors and non-repressors (Barger, Kircher, & Croyle, 1997).

To test how a questionnaire-based grouping was reflected in discrepancy scores between reported and physiological stress levels, Gudjonsson (1981) first used conventional anxiety (TMAS) and defensiveness (MC-SDS) scales and then divided participants into coping style groups based on the discrepancy between their physiological arousal and self-reported affect in response to emotionally disturbing stimuli. As expected, questionnaire-based repressors had elevated SCL but reported little subjective negative mood. Similarly, Brosschot & Janssen (1998) found greater discrepancy between physiological and emotional distress in individuals categorized as repressors by defensiveness (MC-SDS) and trait anxiety (trait version of the State-Trait-Anxiety Inventory, STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) scales, compared to the non-repressor group. Thus, discrepancy scores that calculate the difference between self-reported and more objective physiological stress indices avoid some of the ambiguities in delineating coping styles based on questionnaires alone.

This approach has very rarely been implemented as an *alternative* to questionnaire measures of repressive coping (rather than as an *outcome*). One exception is a study by Coifman and others (2007) who measured repressive coping as an *affective-autonomic response discrepancy (AARD)* defined as the difference between reported affect and skin conductance response during stressful laboratory tasks. Using this approach, Coifman and colleagues (2007) were able to test parametric effects of skin conductance responses, self-reported stress, as well as their interaction (the *AARD*) on their dependent measures of interest (in this case, levels of emotional adjustment after bereavement experiences). I adapted this approach in my thesis and aim to assess coping style along a continuum of autonomic-response discrepancy in the context of a stress task.

1.4 Cognitive Biases in Repressive Coping

The following sections give an overview on cognitive research in individuals with repressive coping style. The framework I used to organize these findings follows one of the most prominent current theories for cognitive biases in repressive coping style, the Vigilance-Avoidance Theory (Derakshan, Eysenck, & Myers, 2007). This theory was developed primarily based on attentional processing changes in repressors, which are discussed prior to memory alterations. First, an overview on Vigilance-Avoidance Theory is provided.

1.4.1 The Vigilance-Avoidance Theory

The Vigilance-Avoidance Theory was proposed to explain patterns of emotional information processing that may facilitate the discrepancy between repressors' reported distress and their physiological stress (Derakshan et al., 2007). The Vigilance-Avoidance Theory originated in Eysenck's theory of anxiety (M. W. Eysenck, 1997). He proposed that the amount of anxiety experienced by a person depends on the level of attention and interpretation of their environment, physiological arousal, and the potential for future threat. The Vigilance-Avoidance Theory defines two stages of information processing specific to repressive coping: (1) 'Vigilance' is here understood as a quick automatic orientation towards a self-relevant threat with the goal to detect it fast. (2) 'Avoidance' refers to controlled and strategic allocation of attention away from self-relevant threat. Both processes are thought to be initiated sequentially (see **Figure 1**).

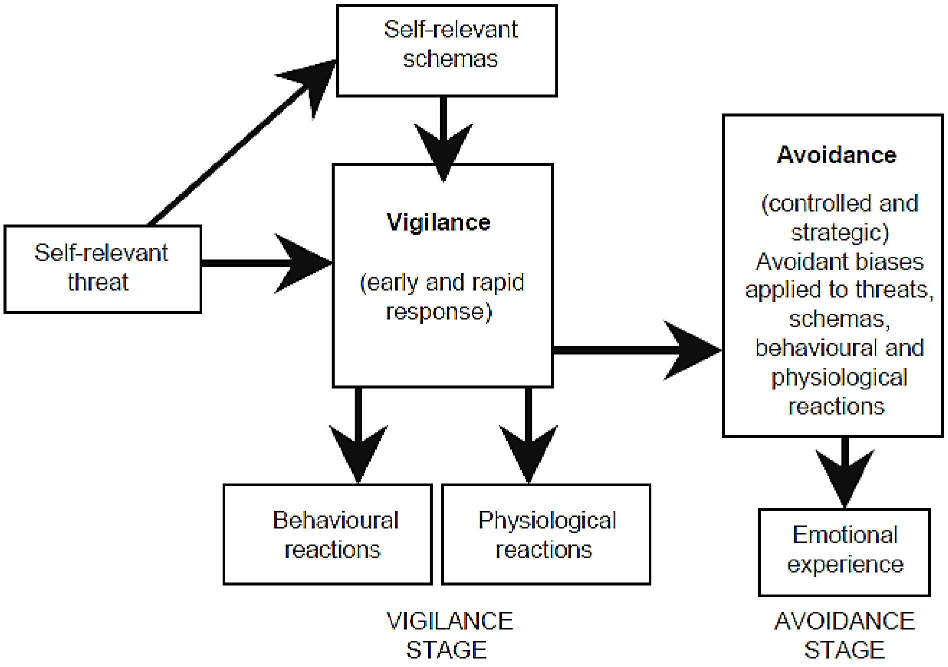


Figure 1. Information processing according to the Vigilance-Avoidance Theory showing the two separate stages of vigilance and avoidance in relation to perceived self-threat (from Derakshan et al. [2007], p. 1590)

According to the Vigilance-Avoidance Theory, psychophysiological discrepancy occurs in repressors because physiological arousal (e.g., as measured by skin conductance changes) indicates the bodily, non-controllable stress response elicited by the *detection of threat* (vigilance), while self-report measures *conscious control* (avoidance). According to this theory, repressors exhibit a stress response to threatening stimuli and as a result they avoid further processing of the threat to reduce the likelihood of experiencing the associated arousal. Thus, the Vigilance-Avoidance Theory agrees with Freudian (Freud, 1957/1915) conceptions of repression, Weinberger and others (1979) as well as Krohne’s (1993) model of coping modes in assuming that the underlying motivation of a repressive avoidance is the unwillingness to experience or express emotional arousal related to (self-relevant) threat. The lack of attention to threatening environmental stimuli, especially when neutral alternatives are present, provides repressors with the option to avoid experiencing internal negative states like feelings of anxiety (Derakshan et al., 2007). Although the Vigilance-Avoidance Theory focuses on the self-relevant threat, studies using non-self-relevant yet negative stimuli have also shown avoidant biases in attention (Avero, Corace, Endler, & Calvo, 2003; Hock & Egloff, 1998; Kline, Allen, & Schwartz, 1998; Mogg et al., 2000) and memory (Hertel & McDaniel, 2010; Krohne & Hock, 2008; Mogg et al., 2000) in repressors. Thus, although vigilance-avoidance mechanisms apply particularly to self-relevant threat processing in repressive coping, this way of processing negative information may extend to non-explicitly self-related information.

1.4.2 Attention Biases in Repressive Coping Style

Most consistent support for the Vigilance-Avoidance Theory comes from attention studies comparing repressive individuals to other coping styles. Across different experimental setups, repressors have been found to be faster in detecting threatening stimuli initially and then to more quickly avoid further processing, compared to non-repressive individuals (Avero et al., 2003; Derakshan, Feldman, Campbell, & Lipp, 2003; Hock & Egloff, 1998; Kline et al., 1998; Mogg et al., 2000). For example, Kline and others (1998) found that repressive individuals (classified via the Eysenck Personality Questionnaire, H. J. Eysenck & Eysenck [1964]) were better than non-repressive participants at identifying unpleasant compared to pleasant words, even when words were quickly masked by a subsequent neutral stimulus. Hock and Egloff (1998) found enhanced performance (vigilance) in repressors (classified by STAI-T and MC-SDS) for threat-related items in a lexical decision task, compared to a recognition memory task. That is, finding implicit memory (priming assessed via lexical decision) biased *towards* threat and explicit memory (recognition) biased *against* threat may be interpreted as another indication of vigilance-avoidance patterns in repressors (but see Fujiwara et al. [2008] who found no differential priming for negative self-relevant threat in repressors). Both of these studies argue that repressors may show enhanced early processing specific to emotionally arousing negative items, possibly in combination with a later-stage avoidance.

A few fMRI studies have investigated the neurological basis of potential repressor-unique threat processing. Rauch and others (2007) tested repressors and sensitizers (categorized using the MCI-R) during the perception of threatening and non-threatening emotional faces in a passive viewing task. Faces were either shown below detection threshold (masked condition: exposure to the faces was limited to 33 msec, at which time a neutral facial expression was shown to mask for the initial face) or above threshold (unmasked condition: 500 msec exposure to each face without a mask). Repressors had greater cortical activity in temporo-occipital regions during processing of fearful (but also of happy) facial emotions than sensitizers, in both the masked and unmasked conditions. These findings were argued to reflect greater engagement of visual processing of fearful (and happy) faces in repressors (i.e., vigilance). In the unmasked condition only, repressors also showed a trend effect (p =0.054) of reduced amygdala activation in response to fearful (vs. neutral) faces compared to sensitizers. Subsequent time series analyses between blood-oxygen-level dependent (BOLD) responses in the amygdala and prefrontal cortex activation (Brodmann area 10) during unmasked fearful face processing found a significantly stronger coupling in repressors than in sensitizers. As repressors' amygdala activity showed a trend of lower activation, this finding suggested that perhaps repressors showed more effective down-regulation of amygdala activity via the prefrontal cortex than sensitizers, at least when the fearful images were consciously processed. This finding provides some evidence for the existence of a (late-onset) cognitive avoidance of fear-related information in repressors.

A follow-up fMRI study by Paul and colleagues (2011) investigated specifically only the vigilance portion of the Vigilance-Avoidance Theory with a similar but higher-powered experimental design, using only masked (33 msec) presentations of fearful, angry, happy, and neutral faces. Repressors were classified via the MCI-R and contrasted with sensitizers. Repressors exhibited stronger BOLD responses than sensitizers to all emotional faces (angry, fearful, happy) compared to neutral faces. Brain regions showing this effect spanned frontal, parietal and temporal lobe regions, as well as anterior cingulate cortex, areas of the basal ganglia and the insula. To establish whether repressors' BOLD responses may show selectivity to potential threat (i.e., angry and fearful faces), an additional contrast showed that repressors also had stronger activations during angry face processing than happy face processing, compared to sensitizers. Behaviourally, repressors and sensitizers both exhibited chance level performance in identifying the emotion of the faces. Thus, repressors were not better at consciously detecting emotional faces despite showing stronger activation of several cortical areas, including prefrontal and anterior cingulate cortex areas involved in emotion regulation, compared to sensitizers. These findings may imply a hypersensitivity in automatic processing of facial stimuli in repressors, i.e., the vigilance portion of the Vigilance-Avoidance Theory, and especially so when the faces exhibit anger. Paul and others (2011) speculate that in repressors specifically, a defensive or ‘avoidant’ process may already be initiated immediately after the initial, presumably unconscious, registration of a briefly flashed emotional stimulus. This interpretation remains speculative as there was no explicit test of cross-regional functional interactions such as the time-series analysis in Rauch and others (2007).

Several studies of rhythmic electroencephalography (EEG) pointed to differences between coping style groups. Without a concurrent task, these studies found higher left frontal than right hemispheric activity (e.g., power in the alpha band) in high defensive individuals, which was usually interpreted as higher dispositional levels of emotional control (avoidance) (Blackhart & Kline, 2005; Kline, Knapp-Kline, Schwartz, & Russek, 2001; Pauls, Wacker, & Crost, 2005; Tomarken & Davidson, 1994). In conjunction with an emotional Stroop task, Vendemia & Rodriguez (2010) used EEG to assess differences between coping styles (repressors, low-anxious, high-anxious, classified by MC-SDS and STAI; females only). Repressors showed higher power in right frontal alpha and in right temporal-posterior beta (specific to negative words) than non-repressors, but no differences in reaction time. The frontal increase in power in the alpha range was tentatively interpreted as indicating increased attentional control. The posterior beta effect, being considered as indicator of emotional processing and vigilance (Crawford, Clarke, & Kitner-Triolo, 1996), was proposed to be associated with repressors’ task vigilance specific to threatening stimuli.

Taken together, fMRI and EEG findings point to both early sensitivity to emotional stimuli in repressors and mixed evidence for an increased engagement of inhibitory processes in early processing stages (Paul et al., 2011) or later processing stages (Rauch et al., 2007), but from these studies it remains unclear when and how these processes engage each other.

A few behavioural studies have investigated the potential switch from vigilance to avoidance. As such, Calvo & Eysenck (2000) used a sentence-completion task where participants (classified by STAI-T & MC-SDS) read a word following a sentence fragment. The sentence, if completed with the word, could have a threatening or a non-threatening meaning. The to-be-named completion word was presented at varying delays of 50 msec, 550 msec, or 1050 msec after each sentence fragment. Repressors showed faster naming of threat-implying words than non-repressors, but only when the word was presented after 550 msec. High-anxious participants showed faster threat-naming latency after word presentation with a 1050 msec delay. Low-anxious participants never showed faster naming of threat compared to non-threat implying words. Thus, repressors showed facilitated early processing of threat, a bias that was shown by high anxious individuals only later on, at which time repressors had resolved their initial vigilance and no longer had a naming advantage for threat implications. Calvo and Eysenck (2000) conclude that high-anxious individuals have a continued bias towards threat, low-anxious have a stable bias towards non-threat, and repressors exhibit a unique early bias towards threat followed by avoidance of threat (see also Caldwell & Newman, 2005).

Another method to investigate the switch from vigilance to avoidance was a study by Schwerdtfeger and Derakshan (2010) using an attentional cuing paradigm (i.e., measuring selective attention) with cue-target onset asynchronies of 250 msec and 750 msec. They demonstrated that repressive coping was associated with faster detection of a dot-target appearing in the same location as a preceding angry (but not neutral) face-cue in the 250 msec condition, but with slower detection in the 750 msec condition. That is, early vigilance (at or before 250 msec in this task) and later avoidance (at or later than 750 msec) was found to be associated with repressive coping in this study. Although the timeline of shift to avoidance is largely determined by the nature and timing of the task, these studies support the notion that repressors might show attentional vigilance for threat cues, and at some point they switch to attentional avoidance of threat.

A few limitations should be mentioned here. First, studies using adaptations of Wegner's thought suppression paradigm (Wegner, Schneider, Carter, & White, 1987; Wenzlaff & Wegner, 2000) showed that while repressors were better able than non-repressors in consciously suppressing (i.e., avoiding) negative thoughts they were told not to think about (Geraerts, Merckelbach, Jelicic, & Habets, 2007), they also experienced increased re-bound of these thoughts (Geraerts, Merckelbach, Jelicic, & Smeets, 2006). That is, even if some form of attentional avoidance is exerted more effectively by repressors, this does not necessarily imply actual deletion of the avoided thought content. Furthermore, attentional vigilance-avoidance patterns are not as specific to repressors as presented in the Vigilance-Avoidance Theory. Such attentional patterns can also be found in high-anxious individuals (Bradley, Mogg, Falla, & Hamilton, 1998; Ioannou, Mogg, & Bradley, 2004; Terburg, Aarts, & van Honk, 2012). To give an example, Terburg and others (2012) investigated the *hypervigilance-avoidance theory* of anxiety using an eye-tracking paradigm and recorded gaze patterns in response to angry and neutral faces in high-anxious people. Terburg and colleagues found a positive correlation between trait-anxiety (assessed with the STAI) and vigilance-avoidance eye gaze patterns to angry but not neutral faces (see also: Ioannou et al., 2004). Research on vigilance-avoidance in anxiety stems from Eysenck's theory of anxiety (M. W. Eysenck, 1997) and Mogg, Bradley, de Bono, and Painter's (1997) proposal of the hypervigilance-avoidance theory of anxiety. Both theories postulate quick detection of threat followed by subsequent avoidance in high anxious individuals. That is, they propose a mechanism of high anxiety that is similar to the mechanism of repressive coping style proposed by the Vigilance-Avoidance Theory.

Taken together, despite a variety of findings suggestive of vigilance-avoidance patterns in attention to threat in repressive coping, further clarification is needed regarding the exact nature and uniqueness of such biases to individuals with a repressive coping style.

1.4.3 Memory Biases in Repressive Coping Style

The Vigilance-Avoidance Theory offers an explanation for repressive coping at attentional processing stages, or – in memory terminology – at the ‘encoding’ stage, but how these initial behaviours may or may not influence later memory remains speculative.

Memory findings in repressive individuals are variable: reductions in memory for negative information are most obvious if repressors are asked to retrieve personally relevant negative information such as negative life events (Davis, 1990; Davis & Schwartz, 1987; Myers & Brewin, 1994) or self-relevant experimental stimuli (Alston et al., 2013; Fujiwara et al., 2008; Saunders, Worth, & Fernandes, 2012), as opposed to simply negative information (e.g., Brosschot, De Ruiter, & Kindt, 1999). In addition, free recall is more consistently impaired than less strategic forms of memory retrieval (Alston et al., 2013; Fujiwara et al., 2008; Oldenburg, Lundh, & Kivisto, 2002; Saunders et al., 2012). As alluded to already, different paradigms targeting the *deliberate* forgetting of negative information have shown that repressors, when told to do so, are better than groups of non-repressors in forgetting or suppressing negative, and especially self-relevant negative information (Barnier, Levin, & Maher, 2004; Geraerts et al., 2007; Geraerts et al., 2006; Hertel & McDaniel, 2010; Myers, Brewin, & Power, 1998). An open question is how attentional vigilance-avoidance patterns of threat processing in repressive individuals may or may not relate to their memory for that same information.

Derakshan and others (2007) propose that memory biases in repressors might be driven by inhibition at retrieval (i.e., late avoidance after successful initial encoding) rather than at encoding. There are experimental findings in accordance with this view (e.g., Davis & Schwartz, 1987; Fujiwara et al., 2008; Geraerts et al., 2006; Shane & Peterson, 2004), resonating with psychodynamic suggestions of repression as a way to sever access to, but not availability of, unpleasant memories. List-methods directed forgetting studies in repressive coping style also point to repressive coping style as influencing the retrieval-stage rather than the encoding stage. For example, Myers, Brewin, and Power (1998) asked individuals to learn a list of negative and positive words and then told to forget these words. Then they asked them to learn another, designated the to-be-remembered list also consisting of negative and positive words. Their findings showed that repressors had lower memory than non-repressors for negative words from the to-be-forgotten list, but intact memory for negative words from the to-be remembered list. Since the instruction to forget the first list is given *after* encoding, effects of forgetting are thought to be retrieval-based. Thus, these repressor-specific findings may indicate a selective ability of repressors to inhibit negative memories at the retrieval stage and not at encoding (see Myers & Derakshan [2004], for further qualifications of this effect).

However, memory biases in repressors may also stem from attention biases at encoding that will then necessarily reduce later retrieval. As such Schimmack and Hartmann (1997) found that repressors rated the presence of unpleasant emotions in hypothetical scenarios less frequently, but not less intensely than non-repressive individuals; this pattern was replicated in a more natural, daily diary study, again with repressors simply reporting fewer but not less intense emotional experiences in their daily life. Their memory for emotional experiences was not disproportionately impoverished when taking into account that repressors had fewer emotional experiences to begin with. That is, according to Schimmack and Hartmann’s (1997) *frequency hypothesis*, repressors’ memory biases were simply a reflection of quantitatively fewer encoded unpleasant memories. Hansen and Hansen (1988; see also Egloff & Krohne, 1996; Hansen, Hansen, & Shantz, 1992) also suggested that repressors’ encoding may drive their memory biases, but they proposed *qualitative* differences from non-repressors. Their studies showed repressors had oversimplified conceptualisations of emotions. Repressors identified and acknowledged secondary emotional connotations of autobiographical memories or emotional facial expressions to a lesser extent than non-repressors (e.g., the amount of experienced anger in a fearful situation; the amount of sadness in a happy facial expression, etc.). Thus, these studies proposed that repressors may possess impoverished associative networks into which emotional memories are being encoded and consequently, fewer retrieval cues to access such memories. Derakshan and others (2007) in turn argue these findings could imply that the avoidance aspect of attentional vigilance-avoidance may hinder *complete* encoding of negative information and therefore result in repressors reporting fewer incidences of emotional discomfort during an experimental task or in daily life. By avoiding stimuli that elicit negative emotional arousal, repressors would have deficient encoding of negative information (and consequently, less to recall later on). This would imply that measures of attention (to threat) should be positively correlated with later memory. To put it differently, the more a repressive individual would exhibit attentional avoidance, the more they would also show later forgetting of that same information.

Yet another possibility is that instead of processing differences at encoding or retrieval, repressors encode negative information but process it differently *during* the delay before later recall. Hock (1996) proposed the *repressive discontinuity hypothesis*, to account for threat-specific memory reductions in repressive individuals that may evolve only after some time has passed. The main underlying findings for this hypothesis come from studies that found repressors (compared to sensitizers according to the MCI) to have intact memory for threat information immediately after encoding, but decreased memory for threat at delayed test intervals (Hock & Krohne, 2004; Krohne & Hock, 2008; Peters, Hock, & Krohne, 2012; but see Alston et al., 2013). The repressive discontinuity hypothesis then postulates that repressors are perceptually vigilant to threat in early information processing stages (note: vigilance here spanning the *entire* timeframe of encoding), but that this vigilance may serve to selectively inhibit (i.e., avoid) further processing afterwards, e.g., due to selective non-rehearsal during memory consolidation phases Thus, the combination of these processes according to the repressive discontinuity hypothesis would keep immediate retrieval of negative or threatening information intact but impoverish delayed memory retrieval (Hock & Krohne, 2004; Krohne & Hock, 2008; Peters et al., 2012). This hypothesis suggests a cognitive mechanism after encoding that may selectively inhibit later negative memories from being recalled.

In summary, although a host of cognitive research in repressive coping style exists, the majority of studies focused either on early stages of information processing like perception, attention, and encoding *or* on later-stage memory retrieval. The principled approach to these findings via the Vigilance-Avoidance Theory is useful, but the terminology surrounding ‘vigilance’ and ‘avoidance’ is quite inconsistent across studies: Cycles of “vigilance-avoidance” have been proposed to take place during very short-lasting subliminal processing of emotional stimuli (Paul et al., 2011) up to a timescale of multiple days between “early vigilance” and “late avoidance” (Krohne & Hock, 2008). Even though the experimental parameters may dictate differences like these, the divergent uses of the same terms make it very difficult to compare and evaluate across studies whether and under what circumstances there are indeed differentiable early/late processing biases regarding negative information in repressive coping style. Furthermore, the link between early attention (encoding) to threat and later memory of that same information is not clear. The most direct way to test potential contingencies between such processes in repressive coping is to assess them both together. This is the approach I take here, using a combination of behavioural and eye-tracking measures of visual attention together with later free recall and recognition memory tasks.

The focus of my study is to understand the differential effect of emotion on attention and later memory as a function of a repressive stress coping style. Potential coping style-specific attentional shifts from early engagement to later avoidance of threat processing and their link to later memory are not clear. Thus, I aim to investigate visual attention patterns towards negative information and memory for negative information as a function of a repressive coping style. Then, I will investigate whether the link between attention and memory changes as a function of repressive coping style.

1.5 Hypotheses

I had the following hypotheses for my study: The set of predictions in Hypothesis 1 include validation of my task parameters. Hypotheses 2 and 3 pertain to specific predictions regarding emotion-cognition interactions as a function of repressive coping style. As the eye-tracking-based emotional subsequent memory effects have not been studied, targeting the modulation of such effect by repressive coping style remained an exploratory aim rather than a directional hypothesis.

Hypothesis 1- Task Validation: I predict that compared to neutral pictures, negative pictures will attract more visual attention. Presenting visual distractors during encoding will reduce picture viewing time. Emotional pictures will be better recalled and recognised than neutral pictures. Viewing time of pictures will be predictive of later recall and recognition. This effect will be stronger for negative than neutral pictures.

Hypothesis 2- Autonomic-Response Dissociation: I predict that individuals with a questionnaire-based repressive coping style (high defensiveness, low trait anxiety) will show an autonomic-response discrepancy (ARD) between physiological (SCL) and self-reported measures of stress after a stress induction task. Repressors will underreport physiological stress levels.

Hypothesis 3a- Attention: Vigilance-Avoidance Theory during attention predicts that ARD (higher levels of repressive coping) shortens the time of initial eye gaze fixations for negative but not neutral pictures (threat vigilance), but also reduces total viewing time for negative pictures, especially when presented with visual distractors (threat avoidance).

Hypothesis 3b- Memory: I predict a negative correlation between ARD and memory (free recall and recognition) for negative pictures but not for neutral pictures.

Additional Aim – Attention-Memory Link: I further explore whether a subsequent memory effect based on picture viewing time is correlated with ARD and qualified by the valence of the stimuli and the presence of visual distractors.

2. METHODS

2.1 Participants

Participants were 120 introductory psychology students at the University of Alberta. The study was approved by the University of Alberta Research Ethics Board. In online testing sessions at the beginning of fall 2012 and winter 2013 semesters, all students enrolled in an introductory psychology course (a total of 2473 in fall 2012, and 1786 in winter 2013) completed the Self-Deceptive Enhancement (SDE) component of the Balanced Inventory of Desirable Responding scale (BIDR; Paulhus, 1991) and the Trait version of the State-Trait Anxiety Inventory (STAI-T; Spielberger et al., 1983). The BIDR-SDE consists of twenty 7-point scaled statements that measure self-deceptive aspects of social desirability, such as beliefs of invincibility and exaggerated optimism (maximum score: 140). The STAI-T consists of twenty 4-point scaled statements measuring trait-anxiety (maximum score: 80). Both scales (see Appendix 3 for STAI-T and BIDR-SDE example items) have been used in prior studies to select individuals with a repressive coping style (Alston et al., 2013; Fujiwara et al., 2008). Only students under the age of 30, without colour-blindness, and with complete demographic/questionnaire data were included.

Participants were categorized into the four coping styles according to Weinberger's classification scheme (Weinberger et al., 1979) based on quartile splits of BIDR-SDE scores (cut-off: 76 and 91 points, for lowest and highest quartile) and median splits on STAI-T scores (44 points) of the 738 eligible students tested in the 2012 fall semester. The selection of participants in the 2013 winter term used the same cut-off scores to ensure consistency across samples. Participants in each semester were classified as repressors (REP: low-anxious, high-defensive), truly low-anxious (LA: low-anxious, low-defensive), truly high-anxious (HA: high-anxious, low-defensive), defensive high-anxious (DHA: high-anxious, high-defensive) individuals were not given access to the project due to their rarity within the population. Based on the BIDR-SDE and STAI-T cut-off scores, equally-sized groups of participants with one of the three coping styles were given online access to self-enroll in the experiments in each semester. Students were not aware of the nature of the experiment at the time of self-enrolling and experimenters were unaware of the participants' coping style at the time of the experiment. Data from 13 participants were excluded: 5 had non-usable eye-tracking data, 1 participant discontinued after encoding, 2 had computer malfunctions, and 5 misunderstood the tasks and did not complete them properly. Details on the final sample of 107 participants are summarized in **Table 1**.

Table 1. *Demographic and questionnaire data of 107 participants*

	Repressors N=35	**High anxious N=44**	**Low anxious N=28**	**Test statistic**	**Group differences**
Age	M= 19.38 ± 1.61	M= 19.27 ± 2.69	M= 19.72 ± 2.89	F[2,104] = 0.30 $p = 0.74$	N/A
Gender (female/ male)	17/ 18	28/16	15/13	$\chi^2[2] = 1.51$ $p = 0.47$	N/A
STAI-T	Md. = 39 (Rg.= 32 – 43)	Md. = 52.5 (Rg.= 45 – 69)	Md. = 42.5 (Rg.= 27 – 44)	$\chi^2[2] = 81.57$ $p < 0.001$[1]	LA = RE*P* < HA[2]
BIDR-SDE	Md. = 103 (Rg. = 91 – 121)	Md. = 70.5 (Rg.= 58 – 76)	Md. = 73.5 (Rg.= 57 – 76)	$\chi^2[2] = 71.83$ $p < 0.001$[1]	LA = HA < REP [2]

[1]: Kruskall-Wallis Test. [2]: Nonparametric post-hoc T+ tests correcting for all pairwise comparisons, M: Mean (Standard deviation); Md.: Median; N/A: not assessed; Rg.: Range

As intended, high-anxious individuals scored higher in the STAI-T than low-anxious participants and repressors, but the latter two did not differ significantly from each other. In addition, low-anxious and high-anxious individuals both had similar levels of defensiveness, and both scored lower than repressors. Participants were selected based on these two questionnaires to validate whether coping style groups were differentiable by their autonomic-response discrepancy.

2.2 Materials

The following sections describe the materials used in the experiment.

2.2.1 Pictures and Norming Task

The stimuli for the encoding and recognition tasks were pictures from the International Affective Picture System (IAPS; Lang et al., 1999) as well as freely available pictures from the internet. A total of 18 undergraduate students from the same introductory psychology course (12 female/ 6 male; age was available only for 13 participants and ranged from 18 to 21 years; M=19 ± 1.08, tested in the winter term 2012) participated in an initial picture norming task. Prior to the norming task, ethical conduct was ensured by a preparatory explanation, as I exposed participants to emotional pictures. Details of this procedure are given in **Appendix 2. Preparatory instructions given to participants before consenting to participate in the norming or the main experiment.** Exclusion criteria for these participants were impaired vision and age of more than 30 years.

A total of 126 negative photos and 126 neutral photos were pre-selected for the norming task. Of these, 94 negative and 56 neutral pictures were from the International Affective Picture System (Lang, 2008). In addition, 32 negative and 70 neutral pictures were selected from the internet to account for content-related dissimilarities between negative and neutral IAPS pictures (i.e., negative IAPS pictures are often very complex scenes with one or many humans, whereas neutral IAPS pictures are often less complex and may contain only one inanimate object). Selected negative pictures contained scenes of violence, upset youth, assault, and war, but not overly gruesome scenes, mutilations, etc., due to the nature of the test situation in the context of a course. Neutral images included café scenes, children doing homework, adults doing daily activities such as eating, driving, or working on files in an office. Initially, each individual negative picture was intended to match one neutral picture based on image content (number of people present, colour-scheme, etc.). For example, a neutral image could contain two people sitting around a campfire, and the matched negative image would be a man kneeling while on fire, next to a soldier. A precise one-to-one matching of neutral to negative pictures could not be maintained in the picture sets as average arousal and valence ratings from the norming task dictated their final selection. As can be seen in **Table 3**, due to the content-based pre-selection of the pictures prior to norming, characteristics of the final pictures were still well-matched across sets. Each picture was edited to a square of 300 pixels by 300 pixels using Adobe Photoshop ®.

Using a picture-rating procedure by Lang and colleagues (Lang et al., 1999; Lang, Bradley, & Cuthbert, 2008) participants were asked to judge all 252 pictures on two dimensions: valence and arousal. Judgements were made using two different nine-point non-verbal rating scales (Self-Assessment Manikins; SAM) for each dimension (see **Appendix 1**: Self-Assessment Manikin (SAM) scale to assess arousal and valence), administered on a computer. Pictures were presented centrally, in random order with no more than two pictures of the same valence in successive trials. Participants first rated each picture on valence and then on arousal or vice versa. Thus, each picture was rated twice but the order of the rating dimensions was counterbalanced across participants. The norming task was self-paced and administered on a computer with E-Prime, version 2.0.8.90 (Schneider, Eschman, & Zuccolotto, 2002). As can be seen in **Table 2**, sets of encoding and recognition items were well-matched for valence and arousal. As intended, negative picture sets were rated substantially more negatively and more arousing than neutral pictures.

Table 2. *Descriptive statistics of the valence and arousal ratings of fixed picture sets used in the encoding and recognition tasks.*

		M (SD)	Minimum (1.0)	Maximum (9.0)	Test Statistic
Arousal Ratings	Encoding Negative (N= 80)	5.75 (0.85)^a	3.89	7.83	F[3,239]= 491.2 p< 0.001
	Encoding Neutral (N= 80)	2.00 (0.48)^b	1.33	4.17	
	Recognition Negative (N= 40)	5.64 (1.05)^a	3.56	7.61	
	Recognition Neutral (N= 40)	2.07 (0.58)^b	1.33	3.67	
Valence Ratings	Encoding Negative (N= 80)	1.96 (0.49)^a	1.39	3.83	F[3,239]= 1058.7 p< 0.001
	Encoding Neutral (N= 80)	5.84 (0.44)^b	4.56	6.94	
	Recognition Negative (N= 40)	2.14 (0.51)^a	1.33	3.11	
	Recognition Neutral (N= 40)	6.09 (0.78)^b	4.28	7.00	

$^{a, b}$= Means that differ in lettering are significantly different from one another, p< 0.001; M= Mean; SD= Standard deviation; N= number of pictures

Picture sets had comparable frequencies of several content-related feature, as shown in **Table 3**.

Table 3. *Picture content (categorization based on involvement of human characteristics).*

	Enc. Neg. (N= 80)	Enc. Neu. (N= 80)	Recog. Neg. (N= 40)	Recog. Neu. (N= 40)	Test Statistic
No people	12	16	8	6	$\chi^2[18] = 13.23$ $p = 0.78$
One person (face close-up)	19	24	11	11	
One person (whole body)	13	15	6	10	
Two people	11	7	6	8	
Group with central figure	11	4	3	2	
Group of people	7	8	2	1	
Human body part	7	6	4	2	

Enc.= Encoding; N= number of pictures; Neg.= Negative; Neu.= Neutral; Recog.= Recognition.

In addition to the picture stimuli, the encoding task contained 160 distractor images. These stimuli were pixel-by-pixel scrambled versions of the 160 encoding task pictures created with a Matlab® script used in Dolcos and McCarthy (2006). This ensured that the 160 distractors had the same average spatial frequency and luminance as the encoding pictures. As visual memory for pictures was expected to be high, all pictures presented in the recognition task (target and lure pictures) were grey-scaled to increase task difficulty[2].

2.2.2 Additional Materials

During the delay period (see below), participants filled out the Toronto Alexithymia Scale (Bagby, Parker, & Taylor, 1994) which assesses self-rated difficulties in understanding and identifying emotions. In addition, participants filled out the Dissociative Processes Scale (Harrison & Watson, 1992; Watson, 2003) designed to identify dissociative characteristics in non-clinical populations. Neither of these questionnaires were used in the current thesis and will therefore not be discussed further. Paper-and-pencil maze tasks (Madan, Fujiwara, Gerson, & Caplan, 2012) were given during the delay period to participants who had completed the questionnaires prior to the end of the delay. These were filler tasks and not analyzed.

2.3 Tasks

The experiment was 90 to 120 minutes in duration and had a fixed sequence of tasks. Prior to the experiment, ethical conduct was ensured by the same preparatory explanation as in the picture norming task (see **Appendix 2. Preparatory instructions given to participants before consenting to participate in the norming or the main experiment.** for details). The experimental time-line is illustrated in **Figure 2**.

---

[2] Ratings in the picture norming task were done only on colour images. Therefore, the grey-scaling of the pictures for the recognition task may have changed their valence and arousal ratings.

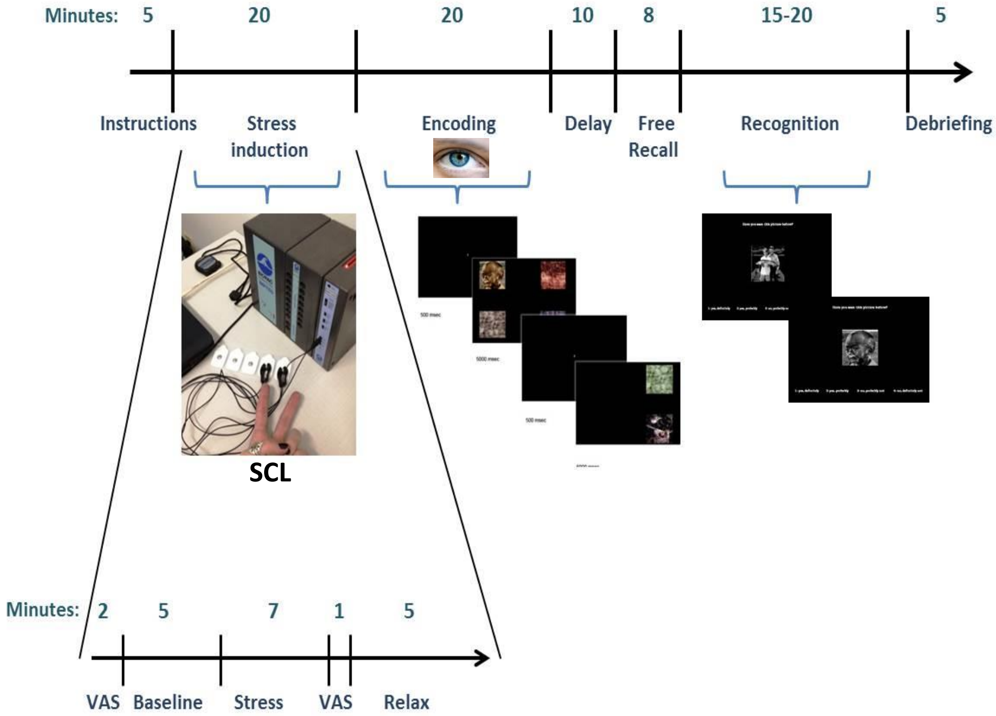
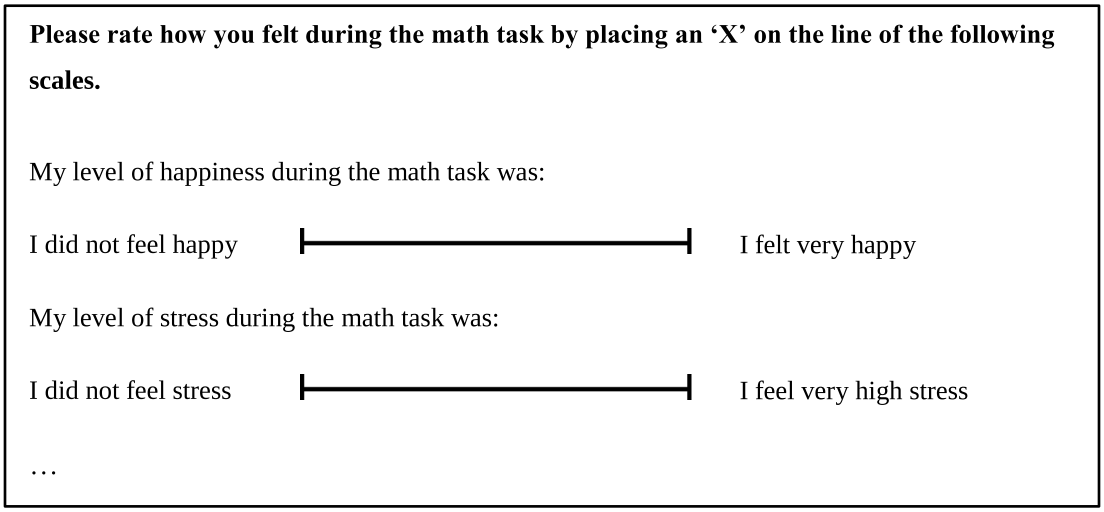


Figure 2. The experimental time-line. VAS: Visual analogue scale. SCL: Skin conductance level.

The experiment was conducted with one participant at a time in a private office in the Research Transition Facility at the University of Alberta. Tests were administered by myself or research assistant Nathan Bartlett. Both testers wore white lab coats to increase the salience of the stress induction task. All computerized tasks were programmed in E-Prime version 2.0.8.90 (Schneider, Eschmann, & Zuccolotto, 2002). A standard Windows laptop connected to an external keyboard and 19-inch LED computer monitor with a screen resolution of 1440 pixels by 900 pixels were used to deliver the experimental tasks to the participants. The details of each part of the experiment are given below, in their order of administration.

2.3.1 Stress Task

Participants first completed a visual analogue scale (VAS), adopted from Coifman et al., (2007) and Jorgensen and Zachariae (2006), where they were asked to indicate their levels of happiness, stress, strength, anxiety, interest, frustration, activity, helplessness, and embarrassment by placing an ‘X’ along a scale measuring 9 cm in length. The scale is illustrated in **Figure 3**. Two VAS scores were calculated, one for overall mood before stress and one for overall mood after stress. The VAS change scores were calculated individually for all 9 domains by subtracting the VAS scores taken after the stress task from those taken before the stress task An overall mood reduction score was derived by taking the mean of all negative VAS change scores (stress, anxiety, frustration, helplessness, embarrassment) and subtracting the mean across positive VAS change scores (happiness, strength, interest, activity). The resulting VAS mood reduction score was therefore scaled so that a high score reflected an increase in reported negative mood after the stress induction compared to before. This overall VAS change score was normally distributed.



Please rate how you felt during the math task by placing an 'X' on the line of the following scales.

My level of happiness during the math task was:

I did not feel happy

I felt very happy

My level of stress during the math task was:

I did not feel stress

I feel very high stress

…

Figure 3. A sample of a positive and a negative item from the visual analogue scale questions from the version following the stress task.

To measure physiological stress via electrodermal activity (EDA: skin conductance signals), participants had two electrodes placed on the volar surfaces of the distal phalanges of the middle and index fingers (left-hand for all participants regardless of handedness). Participants were then asked to restrict as much hand movement as possible for the next task. To establish a baseline skin conductance level, participants were asked to relax for 5 minutes. After the baseline, a 30-second task instruction (stress anticipation) was given. The task was described to participants using the following standardized instructions:

“For the next task we would like to assess an aspect of your intelligence. Your performance will be scored for speed and accuracy. When I say BEGIN you will start with the number 9000 and repeatedly subtract 13 in your head. Try to do this as quickly and accurately as possible. Every 30 seconds I will ask you to tell me the last number you have reached. Do you have any questions? Please begin.”

The 6-minute stress-induction task ensued at approximately 5.5 minutes into the stress induction task. During the stress task, every 30 seconds the experimenter asked and noted which number they had reached. If participants had made an error they were asked to restart from 9000. In addition, every 2 minutes participants were interrupted and verbally reminded that both speed and accuracy were important. Afterwards, participants were asked to fill out the second VAS. Participants were then asked to relax for 5 minutes.

Continuous recordings of EDA before, during, and after the stress task (i.e., baseline, stress anticipation during instruction, stress, relaxation) were measured using pre-gelled EL507 Ag/AgCl electrodes with 2 LEAD100A leads, connected to a Biopac MP150 hardware system with the GSR110C attached component. The GSR110C resistance setting was at 5 µ℧/V, high-pass filter set to off, DC (direct current), and a DC gain setting (Biopac Systems, 2000). EDA data was gathered on a separate laptop that was connected via Ethernet with the GSR110C and analyzed using AcqKnowledge 4.0 software (Biopac Systems Inc.). Analysis of the stress response was done using the tonic EDA, a continuous signal referred to as skin conductance level (SCL), caused by sweat secretion activated by the sympathetic nervous system in response to stress (Boucsein, 2012). Readings of mean SCL amplitude (µSiemens) were acquired every second. In addition, mean SCL was binned into 10-second intervals as well as across four specific time intervals: baseline, instruction of task, stress task, and relax period. The baseline mean amplitude was subtracted from the amplitude during the stress task to determine the change in SCL and infer the participants’ physiological stress reactivity. A higher SCL change score indicates greater increase in skin conductance during the stress task. SCL change scores were not normally distributed and therefore square-root transformed.

2.3.2 Autonomic Response Discrepancy

An index of autonomic response discrepancy (ARD) was calculated, following previous studies that compared self-reported stress and physiological stress in the context of repressive (and non-repressive) stress coping style (Asendorpf & Scherer, 1983; Brosschot & Janssen, 1998; Coifman et al., 2007; Gudjonsson, 1981; Jorgensen & Zachariae, 2006; Pauls & Stemmler, 2003). Repressors are often found to be those who exhibit under-reporting of physiological stress compared to other coping style groups. Therefore the discrepancy between self-reported and physiological stress can be a continuous representation of repressive coping style. First, each individual's SCL change score was z-transformed based on the entire group's average SCL change from baseline to stress task. Secondly, the VAS change scores were z-transformed based on average increase in negative mood after the stress induction task, the VAS change score, in the entire group. The ARD was derived by adding the two z-transformed VAS and SCL change scores, reflecting the degree of autonomic (SCL) and response (VAS) discrepancy. Higher ARD scores represent a relative under-reporting of stress (more physiological arousal during the stress task compared to the average of all participants and less self-reported negative mood compared to all participants) and lower scores represent over-reporting of stress. Therefore an individual's ARD score represents their autonomic response discrepancy, along a continuum, in comparison to all participants in this experiment.

2.3.3 Attention/Encoding Task

The encoding task consisted of 160 trials. Stimuli contained the fixed set of 80 negative pictures, 80 neutral pictures, and 160 scrambled images (distractors). Stimuli were presented in random order, with no more than two pictures of the same valence presented in succession. Distractors were re-used throughout the task, but no two identical distractors were shown in the same trial. Screen locations occupied by the stimuli were one of four quadrants (pixel coordinates beginning with x and y at zero in top left corner of screen. The stimulus coordinates were as follows: quadrant 1: x= 290-590, y= 20-320, quadrant 2: x= 850-1150, y= 20-320, quadrant 3: x= 290-590, y= 580-880, quadrant 4: x= 850-1150, y= 580-880). Appearance of pictures or distractors in each of the four quadrants was randomized, but pictures in successive trials were not shown in the same location.

After a 500 msec fixation cross, stimuli were presented on the screen for a fixed period of 5 seconds. In each trial, 1 picture (negative or neutral) was shown either alone or accompanied by 1, 2, or 3 distractors. Participants were asked to count the number of all items (i.e., 1, 2, 3, or 4) on the computer screen using the F, Y, U, and K keys on the keyboard, which were covered with numbered stickers (1, 2, 3, and 4, respectively). Incorrect trials and those with response times shorter than 200 msec post-stimulus onset were excluded. The trial sequence in the encoding task is outlined in **Figure 4.**

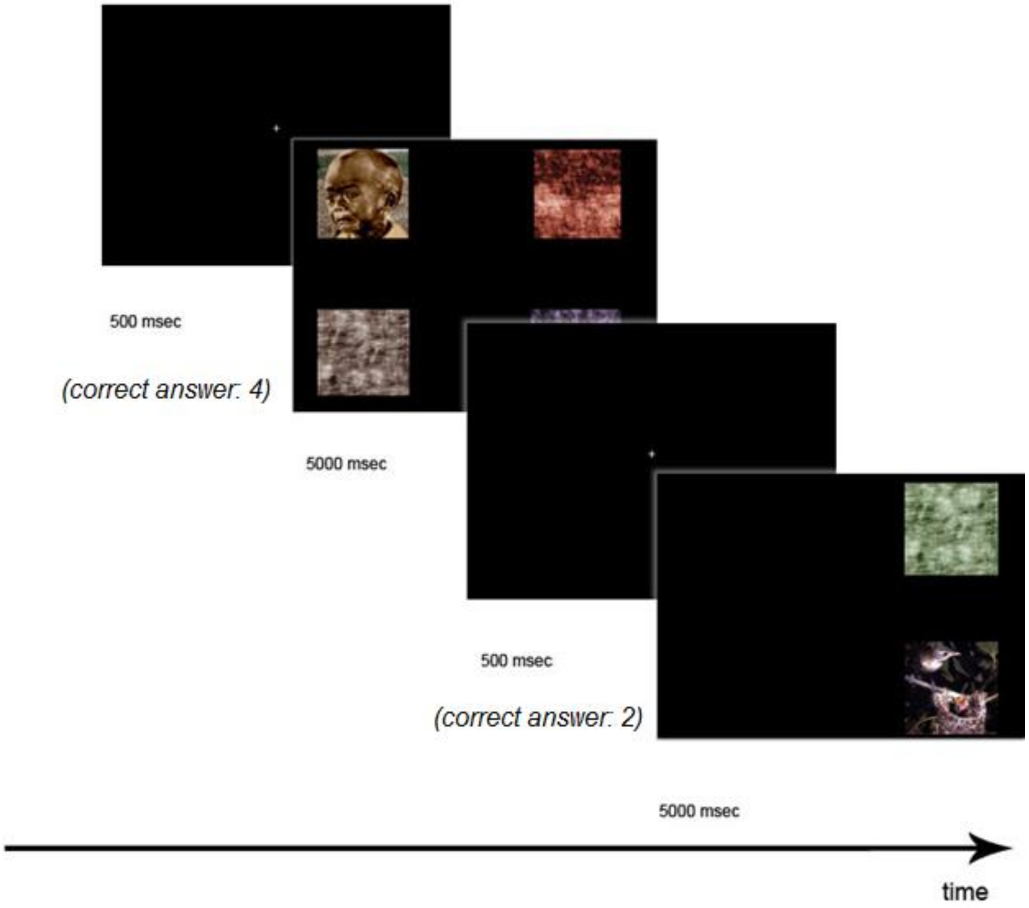


Figure 4. Two example trials in the encoding task.

Eye-tracking recordings were acquired during the encoding task only. A SmartEye eye-tracking system was used (www.smarteye.se). Eye-tracking data were recorded with SmartEye extension for E-Prime (v.2.0.8.90) and with SmartEye Pro 5.9 ® software, on a dedicated desktop computer connected to the hardware. The hardware consisted of two Sony HR-50 12 mm lens infrared lights on the left and right edges of the computer screen and two infrared cameras, operating at 60 Hz. Cameras, positioned underneath the computer screen, detected the infrared light reflected from the participant's face. The reflections of the infrared lights, termed "glints", on the cornea provide a reference point for the SmartEye system which is then able to locate the pupil in each eye. The movement of the glints recorded by the infrared cameras are used to infer gaze direction. To ensure the most accurate data acquisition, an individual head model was created for each participant, using facial features (eyes, nostrils, mouth: see **Figure 5**).

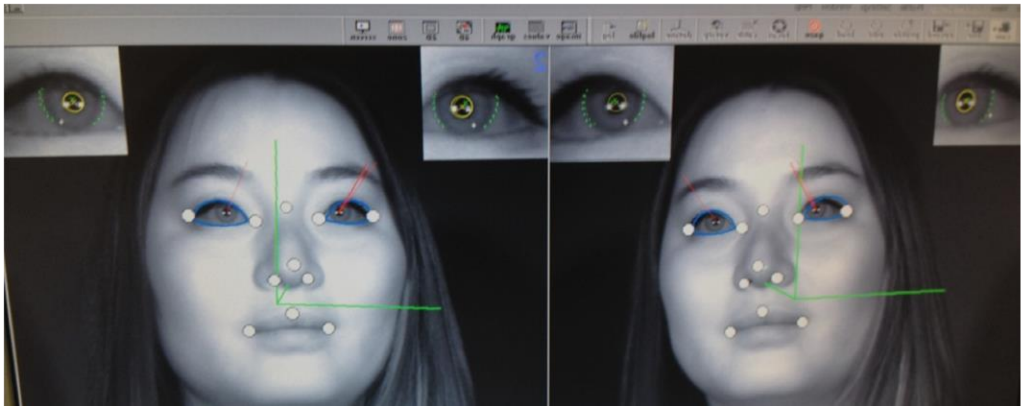


Figure 5. Individual facial features detected along with pupil dilation (yellow) and eye gaze location (red lines) by the SmartEye Pro software.

The setup provided approximately 180° field of view. The eye-tracker was synchronized with the laptop operating the stimulus delivery (see **Figure 6** for an illustration of the setup).

Figure 6. The eye-tracking hardware setup.

Eye-tracking data was recorded at 60 Hz in the form of x and y coordinates representing the participant's eye fixation to areas within the computer screen. Fixations were defined as a gaze velocity below 15 degrees of change per second and calculated using a velocity-based algorithm provided by SmartEye. The location of fixations was determined by calculating whether the coordinates of the participant's gaze fell within or outside the range of the x- and y- coordinates of the quadrant occupied by the picture. Three dependent variables were calculated: The sum of all fixations to pictures per trial (i.e., the total amount of time that fixation coordinates fell within a picture's coordinates), the sum of all fixations to non-picture screen locations per trial and the time-point of the first picture fixation per trial.

2.3.4 Delay

During a fixed delay period of 10 minutes following the encoding task, participants filled out the Toronto Alexithymia Scale (Bagby et al., 1994) and the Dissociative Processes Scale (Harrison & Watson, 1992; Watson, 2003) followed by the maze task (Madan et al., 2012), if there was time remaining.

2.3.5 Free Recall Task

After the delay, participants were given 8 minutes to describe, in any order, as many pictures as they could recall from the encoding task. The verbatim script was as follows:

"For the next 8 minutes I would like you to write down as many of the pictures from the first task that you can remember. Please write a brief description but enough so I know which picture you're talking about, so be specific."

While displaying an example picture (see **Figure 7**) to the participant the experimenter then explained:

"For example, to describe this picture don't just say 'a baby' but, for example, 'a crying, starving baby'. You will have 8 minutes to do this task and I will let you know when the 8 minutes are up."

Figure 7: Example picture shown in the beginning of the free recall task

At the 1-minute and 3-minute mark the experimenter asked the participants about the number of images they had described.

2.3.6 Recognition Task

The recognition task contained all 160 pictures from the encoding task (80 negative, 80 neutral) as well as lure pictures (40 negative, 40 neutral), in grey-scale.

Pictures were individually presented in the center of the screen, in random order, with no more than two pictures of the same valence and no more than two pictures from the same category (targets or lures) presented in succession. Using the number-covered F,Y,U, and K keys (the same keys as in the encoding task), participants performed a one-step recognition task with two levels of confidence-ratings (see Dougal and Rotello [2007] for similar methods): Participants indicated whether each picture was one they had seen previously in the encoding task or not, by using a four-point answering scale: (1) yes, definitely; (2) yes, probably; (3) no, probably not; (4) no, definitely not (see

Figure 8 for an example trial of the recognition task). The task was self-paced, i.e., trials proceeded as soon as participants had made their response. For half of the participants the order of the recognition response options was reversed.

Their choices were: (1) no, definitely not; (2) no, probably not; (3) yes, probably; (4) yes, definitely.

Figure 8. Two example trials in the recognition task.

Recognition task data were analyzed using recognition sensitivity (d-prime), a signal-detection measure that takes both recognition hits and false alarms rates into account (Macmillan, 1993; Stanislaw & Todorov, 1999). Briefly, d-prime (or d') can be calculated by using the Φ-function and its inverse (Φ^{-1}), that assess the proportion of the normal distribution lying to the left (or right) of the z-transformed hits/false alarms rates in a given yes/no signal detection task (or 'old'/ 'new' responses in recognition memory). Following Macmillan (1993), d-prime is determined as:

$$\text{d-prime} = \Phi^{-1}(H) - \Phi^{-1}(F),$$

where H denotes the hit rate (hits / total number of old items) and F denotes the false alarms rate (false alarms / total number of lure items). The Φ- and inverse Φ-functions are incorporated into SPSS and following Stanislaw and Todorov (Stanislaw & Todorov, 1999), d-prime was calculated here using SPSS as:

$$\text{d-prime} = \text{PROBIT}(H) - \text{PROBIT}(F),$$

again, where H denotes the hit rate and F denotes the false alarms rate.

High scores in d-prime indicate successful differentiation between old items and new items, i.e., the ability to endorse old items as old and new items as new. A high d-prime therefore reflects good recognition sensitivity or high quality of recognition memory performance.

Response bias (β), another measure of recognition memory performance based on signal detection theory (for more details see Stanislaw & Todorov, 1999) was also calculated. Β is independent of d-prime and assesses whether an individual prefers one type of answer (i.e., ‘old’ or ‘new’ answers) over the other, *regardless* whether the answer is correct or wrong. A liberal response bias is characterized by a preferred use of ‘old’ compared to new responses, and a conservative response bias is characterized by preferring ‘new’ responses over ‘old’ responses. As for d-prime, Φ- and inverse Φ-functions are used for β calculation. A simplification of Brophy’s (1986) formula for β results in:

$$\beta = e\left(\frac{[\Phi^{-1}(F)]^2 - [\Phi^{-1}(H)]}{2}\right)^2$$

Implemented in SPSS (Stanislaw & Todorov, 1999), the formula used here was

β = EXP (PROBIT(hit) ∗∗ 2 - PROBIT(false alarm) ∗∗2) / 2)

Positive β scores indicate a conservative response bias (preferring ‘new’ responses over ‘old’ responses) and negative β scores indicate a liberal response bias (preferring ‘old’ responses over ‘new’ responses). Proportions of zero or 1 for either hit rate or false alarm rate are undefined, resulting in missing d-prime or β scores. Therefore, following Stanislaw and Todorov (1999), I adjusted hit/false alarm rates of 1 by using the formula: (N - 0.5) / N, where N denotes the number of trials. Zero hit/false alarm rates were adjusted as: (0.5 / N). d-prime and β-scores were calculated separately for confident and non-confident recognition responses.

2.3.7 Debriefing

All participants were debriefed about the intent of the stress task, the purpose of the study, and were offered to read over relaxing positive reframing statements to reduce any residual stress.

2.4 Calculation of Emotional Enhancement of Memory and Subsequent Memory Effects

The emotional enhancement of memory (EEM) was calculated for both free recall and confident recognition. These scores reflect the *relative* advantage of negative over neutral picture recall and recognition. The scores were derived as follows:

$$EEM_{FR} = \text{Negative recalled} - \text{Neutral recalled}$$

$$EEM_{RECOG} = (\text{Neg. hits} - \text{Neg. false alarms}) - (\text{Neu. hits} - \text{Neu. false alarms})^{3}$$

with ‘EEM’ indicating emotional enhancement of memory, FR indicating free recall, RECOG indicating confident recognition, ‘Neg.’ indicating negative pictures, ‘Neu.’ indicating neutral pictures and hits/false alarms indicating proportional recognition rates. Of note, rates of non-confident recognition

---

[3] An analogous index of an emotional enhancement of memory (EEM) composite d-prime score was calculated as well but is not further detailed here.

judgements were very low (see Results section for details) and therefore EEM was not calculated for non-confident recognition. Furthermore, false alarm rates were also very low, and therefore here combined both confident and non-confident false alarms.

In an analogous manner, the EEM was calculated separately for solitary pictures and pictures with distractors.

$\text{EEM}_{\text{FRsolitary}}$ = Negative solitary, recalled – Neutral solitary, recalled

$\text{EEM}_{\text{FRdistractor}}$ = Negative distractor, recalled – Neutral distractor, recalled

$\text{EEM}_{\text{RECOGsolitary}}$ = (Neg. solitary hits – Neg. false alarms)
– (Neu. solitary hits – Neu. false alarms)

$\text{EEM}_{\text{RECOGdistractor}}$ = (Neg. distractor hits – Neg. false alarms)
– (Neu. distractor hits – Neu. false alarms)

with ‘EEM’ indicating emotional enhancement of confident recognition memory, ‘solitary’ indicating solitary picture trials, and ‘distractor’ indicating picture trials with distractors.

For the purpose of my exploratory aim, I investigated the subsequent memory effect (SME) using the following calculation for both free recall and recognition:

SME_{FR} =VD recalled - VD not recalled

$\text{SME\_confident}_{\text{RECOG}}$ =VD confident hits - VD misses

$\text{SME\_non-confident}_{\text{RECOG}}$ =VD non-confident hits - VD misses

with ‘SME’ indicating subsequent memory effect and VD indicating viewing duration. As the hit rate in the recognition task was high, and consequently, misses were low, viewing times for missed/forgotten items comprised both confident and non-confident “new” judgments to old target pictures. Viewing duration indicates the duration (in msec) that participants looked at a picture during the encoding task. Thus, the SME indicates view time differences at encoding that were later indicative of successful recall or recognition. For free recall and confident recognition memory, SME was also calculated separately within each of the four conditions:

$SME_{\text{FR negative, solitary}}$ = VD negative solitary, recalled - VD negative solitary, not recalled

$SME_{\text{FR negative, distractor}}$ = VD negative distractor, recalled - VD negative distractor, not recalled

$SME_{\text{FR neutral, solitary}}$ = VD neutral solitary, recalled - VD neutral solitary, not recalled

$SME_{\text{FR neutral, distractor}}$ = VD neutral distractor, recalled - VD neutral distractor, not recalled

$SME_{\text{RECOG negative, solitary}}$ = VD negative solitary, hits - VD negative solitary, misses

$SME_{\text{RECOG negative, distractor}}$ = VD negative distractor, hits - VD negative distractor, misses

$SME_{\text{RECOG neutral, solitary}}$ = VD neutral solitary, hits - VD neutral solitary, misses

$SME_{\text{RECOG neutral, distractor}}$ = VD neutral distractor, hits - VD neutral distractor, misses

2.5 Statistical Analyses

Statistical analyses were carried out with IBM-SPSS, version 21, IBM ®. All data were first tested for normality using Kolmogorov-Smirnov test. If normality violations were detected, data were transformed in the conventional order from least to most transformation (square-root, logarithmical, inverse transformation: Tukey, 1977).

First, basic effects of emotional valence and presence/absence of distractors on task performance were assessed to address all aspects of hypothesis 1 (task validation). For encoding, four repeated-measures 2 x 2 ANOVA were conducted with within-subject factors valence (negative/neutral) and distractor (solitary picture/picture with distractors[4]). Dependent variables in these four encoding task analyses were response times (square-root transformed), viewing durations of pictures, viewing duration of non-picture screen areas, and time-point of first picture fixation (inverse-transformed). A non-parametric Friedman test was conducted on highly skewed free recall of all four combinations of valence (negative/neutral) and distractor (solitary picture/picture with distractors). For recognition performance, dependent variable d-prime was analyzed with a 2 x 2 x 2 ANOVA with within subjects-factors confidence (confident /non-confident), valence (negative/neutral), and distractor (solitary picture/picture with distractors). As the β-scores had a highly skewed distribution, a non-parametric Friedman test was conducted on all combinations of confidence (confident/non-confident), valence (negative/neutral), and distractor (solitary picture/picture with distractors). To test relationships between attention and memory, subsequent-memory effects were tested against zero with T-tests to assess their presence/absence. Then, analogous repeated measures ANOVA were conducted, as described above. Parametric and non-parametric ANOVA results requiring follow-up were tested with post-hoc t-tests.

To address hypothesis 2 and assess whether questionnaire-based coping style groups differed in ARD, a one-way ANOVA was conducted on ARD with group as a factor. Furthermore, I also compared the two components of the ARD (change in SCL and VAS) across questionnaire-based groups. For this purpose, a repeated measures ANOVA was conducted on skin conductance level (amplitude) as a function of ‘time’ (in 10-second bins) and ‘group’ (repressor, low-anxious, high-anxious). The comparisons between coping style and self-reported stress (VAS: visual-analog scale) was calculated using the mean difference between VAS scores before and after the stress task. These scores were compared across coping style groups using one-way ANOVA.

---

[4] Presenting more than one distractor was necessary to make the item-counting task during the encoding phase viable. This was originally intended to parametrically increase visual processing load. However, retaining a four-level factor (0, 1, 2, 3 distractors) resulted in excessive loss of data, especially in low performance variables such as in free recall. To avoid data loss and simplify the analyses, I combined the presence of 1, 2, and 3 distractors into one level (picture with distractors), contrasted with the zero distractor condition (solitary picture).

To address hypotheses 3 a & 3 b, correlations were conducted in all participants (N=107) assessing relationships between ARD (and its constituents SCL and VAS) and encoding task accuracy, viewing durations of pictures and non-picture areas on the screen, time-point of first picture fixation, free recall, recognition (d-prime & β), the emotional enhancement of memory (EEM), as well as the size of the subsequent memory effects (to address my exploratory aim). These were Pearson correlations or Spearman rank correlations, as indicated. Four task variables were used within each set of correlations, denoting performance on negative solitary pictures, negative pictures with distractors, neutral solitary pictures, and neutral pictures with distractors. To control for false-positive findings but retain maximal sensitivity, the significance threshold for each set of correlations was adjusted by a factor of 4, i.e., $p < 0.0125$. Uncorrected p's of $p < 0.05$ are also provided.

3. RESULTS

3.1 Behaviour & Task Validation

The first set of analyses was conducted to address hypothesis 1 and illustrate general performance patterns in all parts of the experiment, irrespective of coping style.

3.1.1 Attention

Encoding task accuracy (i.e., counting the number of items on the screen) was close to ceiling ($M = 96\% \pm 3\%$) and therefore will not be further discussed. The average response time for all correct responses was 1165.89 ± 438.1 msec.

Negative pictures were predicted to attract more attention than neutral pictures. Therefore, response times in trials with negative pictures were expected to be slower than in trials with neutral pictures. In addition, having multiple items on the screen was also expected to slow response times, compared to trials with a solitary picture. Comparing (square-root transformed) response times as a function of valence and distractor, I found main effects of valence ($F[1,106] = 50.62$, $p<0.001$, $\eta^2_{\text{partial}} = 0.32$) and distractor ($F[1,106] = 104.60$, $p<0.001$, $\eta^2_{\text{partial}} =0.50$), but no interaction ($F[1,106]= 0.97$, $p = 0.33$, $\eta^2_{\text{partial}} = 0.01$). Reaction times in all four conditions are illustrated in **Figure 9**.

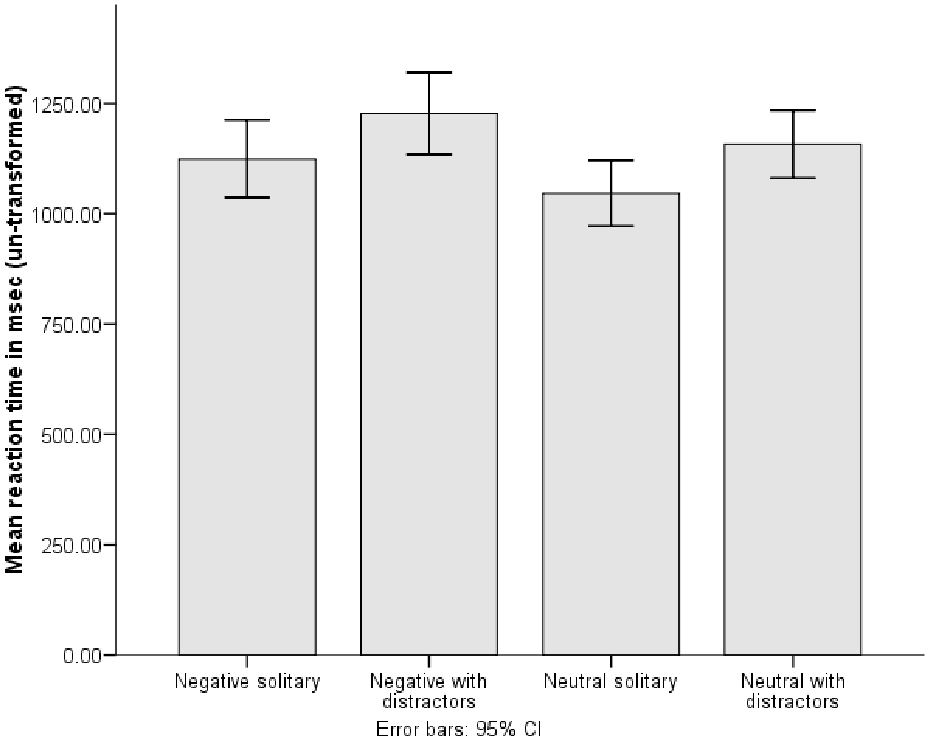


Figure 9. Mean reaction times of correct responses at encoding. For illustration, data are shown untransformed.

Back-transformed average reaction times to negative pictures (*M*= 1158.47 msec, 95% CI [1072.5, 1264.68]) were longer than those to neutral pictures (*M*= 1096.74 msec, 95% CI [1024.88, 1171.16]; t[106] = 7.17, $p <$ 0.001). Participants also took longer to count items in trials with distractors (M= 1155.12 msec, 95% CI [1076.39, 1236.63]) compared to counting one picture in solitary picture trials (M= 1047.63 msec, 95% CI [972.5, 1125.52]; t[106] = 10.20, $p <$ 0.001). Thus, presence of negative pictures and presence of distractors in the encoding task slowed response time, as expected.

3.1.2 Eye Tracking

I expected that, analogous to the reaction time data, individuals would spend more time looking at negative than neutral pictures and less time looking at pictures when accompanied by distractors, compared to pictures presented alone.

Participants' average viewing duration of each picture was $M = 2355.16 \pm 763.51$ msec. I found main effects of valence ($F[1,106] = 171.27$, $p < 0.001$, $\eta^2_{partial} = 0.62$) and distractor ($F[1,106] = 325.29$, $p < 0.001$, $\eta^2_{partial} = 0.75$) on picture viewing duration, qualified by a 2-way interaction between valence and distractor ($F[1,106] = 27.22$, $p < 0.001$, $\eta^2_{partial} = 0.20$). As can be seen in **Figure 10** (left panel), viewing durations were longer for negative than neutral pictures, and within each valence, there was a longer viewing duration of solitary pictures than viewing duration of pictures with distractors. However, the prolonged viewing durations due to the absence (versus presence) of distractors was more pronounced for neutral pictures (viewing time of neutral solitary pictures minus viewing time of neutral pictures with distractors: $M = 608.87$ msec ± 372.97 msec) than for negative pictures ($M = 440.67$ msec ± 312.51 msec; $t[106] = 5.22$, $p < 0.001$). Thus, the presence of distractor items decreased the viewing time of neutral pictures more than view time of negative pictures.

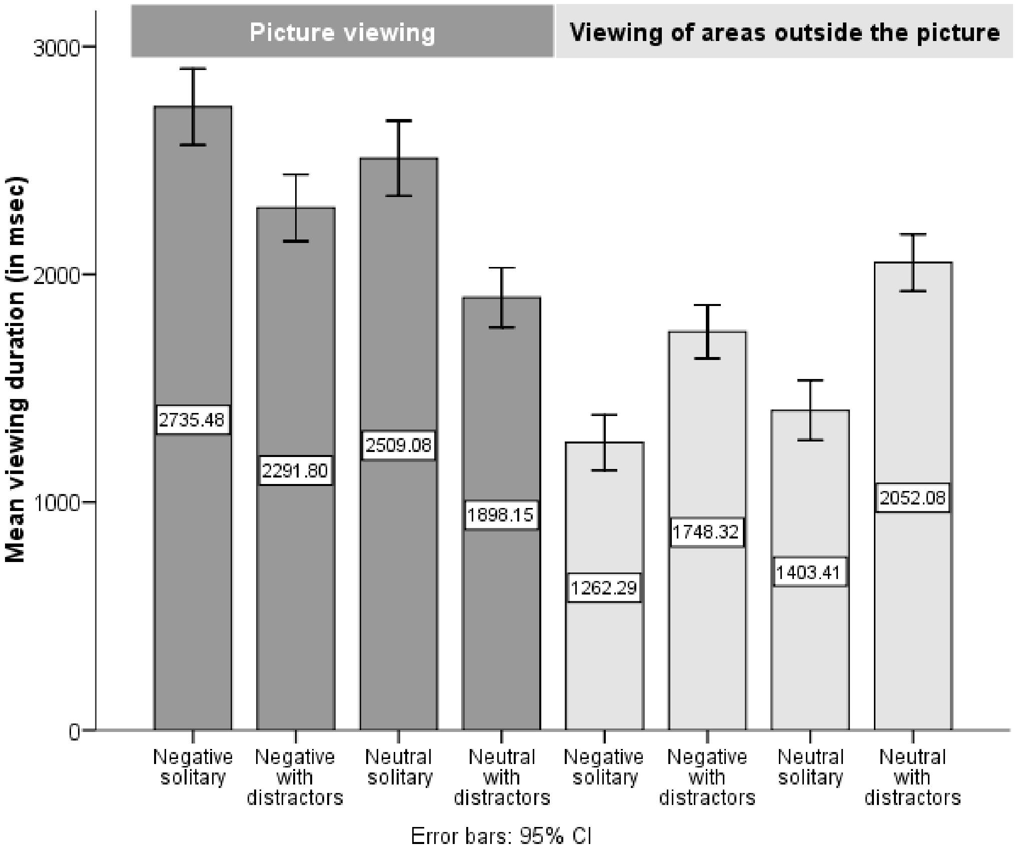


Figure 10. Mean viewing durations (in msec) of pictures (dark grey) and screen areas outside the pictures (light grey) by valence and distractor.

Of the five seconds in each trial, participants spent an average time of M = 1616.52 ± 607 msec looking on screen areas outside the pictures. The analogous ANOVA on viewing durations of screen areas outside the pictures (M = 1616.52 ms ± 607.12 msec) also showed a main effects of valence ($F[1,105] = 105.09$, $p < 0.001$, $\eta^2_{partial} = 0.50$) and distractor ($F[1,105] = 338.79$, $p < 0.001$, $\eta^2_{partial} = 0.76$), as well as the interaction between valence and distractor ($F[1,105] = 34.38$, $p<0.001$, $\eta^2_{partial} = 0.25$; see **Figure 10,** right panel). Complementary to picture viewing times, viewing durations of areas outside the pictures were shorter for negative than neutral pictures and shorter for solitary pictures than pictures with distractors. In addition, differential viewing of screen locations outside the pictures due to the absence of distractors was more pronounced with neutral pictures (viewing time of screen locations outside pictures with distractors minus viewing times of screen locations outside solitary pictures; neutral picture trials: M = 303.76 msec ± 246.3 msec) than with negative pictures (M = 141.12 msec ± 282.72 msec; $t[105] = 5.86$, $p < 0.001$). Thus, the presence of distractor items did not increase viewing times of screen locations outside negative pictures to the same extent as it increased viewing times of screen locations outside neutral pictures[5].

The presence (versus absence) of distractor items on the screen was expected to cause a delay in the first fixation to the picture and it was expected that negative pictures might be more quickly fixated than neutral pictures. The time-point of first fixation to a picture was analyzed for this purpose. Inverse-transformation had to be conducted on time-points of first picture fixations to achieve normality. First picture fixation time-point was analysed with analogous 2 x 2 ANOVA. I found a main effect of distractor ($F[1,106] = 271.37$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.72$), but neither main effect of valence ($F[1,106] = 1.97$, $p = 0.16$, $\eta^2_{\text{partial}} = 0.02$, nor an interaction ($F[1,106] = 0.49$, $p = 0.49$, $\eta^2_{\text{partial}} = 0.005$). Participants fixated earlier to the picture when no distractors were present (M = 289.39 msec, 95% *CI* [272.078, 309.04]) compared to when there were distractors on screen (M = 434.78 msec, 95% *CI* [400.95, 454.55], $t[106] = -16.47$, $p < 0.001$).

Taken together, the eye-tracking results are in general agreement with the response time data: Participants spent more time looking at negative compared to neutral pictures and less time looking at the pictures when distractor items were present. In addition, the presence of distractor items did not decrease viewing time to negative pictures to the same extent as in the neutral condition and did not increase viewing times to screen locations outside the picture in negative picture trials to the same extent as in neutral picture trials. As the time-point of first picture fixation was only significantly slowed down by the presence of distractors

---

[5] Although this may seem redundant, the results of the analyses of viewing durations of screen areas outside the pictures themselves are highly complementary and similarly robust as those with viewing times of the pictures themselves. This shows the reliability of the measurement as well as task compliance of the participants: They looked away from the picture in distractor trials, as intended, rather than closing their eyes.

on screen, regardless of valence, these findings together imply that negative pictures held visual attention longer but did not initially attract faster visual orienting.

3.1.3 Free Recall

Negative pictures were expected to be better recalled than neutral pictures; in addition, solitary pictures were expected to be better recalled than pictures presented with distractors. On average, participants' recall proportion out of the 160 pictures was $M = 0.11 \pm 0.04$ (i.e., participants recalled on average 17.97 ± 5.6 pictures). Recall proportions were highly skewed and non-correctable by transformation. Therefore, a non-parametric Friedman Test was performed. This test relies on rank-transformation of the data.

There were highly significant differences in mean ranked free recall proportions (see **Figure 11**: $\chi^2[3]= 181.37$, $p < 0.001$). Correcting for all pairwise comparisons, post-hoc tests on differences between mean ranks (incorporated in SPSS v.21) showed significantly higher ranks for recall proportions of negative than neutral pictures both in the solitary picture condition ($T+ = 9.58$, adjusted $p < 0.001$) and in the distractor condition ($T+ = 8.79$, adjusted $p < 0.001$). Recall of solitary pictures did not differ from recall of pictures with distractors within either valence (negative: $T+ = 0.132$, adjusted $p = 1$; neutral: $T+ = 0.93$, adjusted $p = 1$).

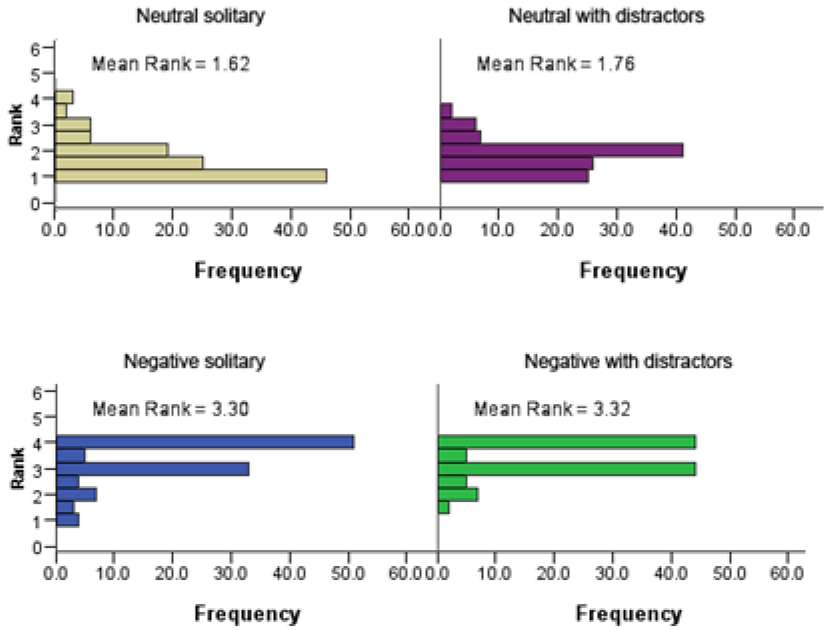


Figure 11. Mean ranks of free recall proportions.

As expected, negative pictures were substantially better recalled than neutral pictures, confirming emotional enhancement of memory (EEM) in the free recall measure. However, recall did not vary as a function of presence/absence of distractors.

3.1.4 Recognition

I expected effects of valence and presence/absence of distractors to be similar in recognition memory as in free recall, and especially so, when assessing confident recognition memory judgements. Thus, I predicted that d-prime will be greater for negative pictures compared to neutral pictures and greater for solitary pictures than pictures presented with distractors.

As outlined in more detail in the Methods section, separate d-prime and β-scores were calculated for confident and non-confident recognition judgements. Means and standard deviations of all hit-rates/false alarms rates incorporated into d-prime/β-scores are summarized in **Table 4**.

Table 4. *Means and standard deviations of confident/non-confident hit and false alarm rates in the recognition task*

	Confident Judgements		**Non-Confident Judgements**	
	Hit/FA rate	**Adjusted scores**[a]	**Hit/FA rate**	**Adjusted scores**[a]
Old Pictures (Targets)				
Negative solitary (N=20)	0.74 ± 0.17	3	0.08 ± 0.06	38
Negative with distractors (N=60)	0.70 ± 0.14	0	0.07 ± 0.05	12
Neutral solitary (N=20)	0.56 ± 0.18	0	0.10 ± 0.09	32
Neutral with distractors (N=60)	0.48 ± 0.16	0	0.10 ± 0.07	7
New Pictures (Lures)				
Negative (N=40)	0.04 ± 0.04	35	0.04 ± 0.05	38
Neutral (N=40)	0.03 ± 0.04	59	0.05 ± 0.06	34

[a]: Numbers of participants with hit rates or false alarms rates of 0 or 1. Their scores were adjusted (details see Methods section) for calculation of d-prime and β. FA= false alarm.

First, a repeated-measures 2 x 2 x 2 ANOVA was conducted on d-prime, with within-subject factors confidence (confident/non-confident judgements), valence (negative/neutral) and distractor (solitary picture/picture with distractors). I found main effects of confidence ($F[1,106] = 1073.63$, $p < 0.001$, $\eta^2_{partial} = 0.91$), valence ($F[1,106]= 22.92$, $p < 0.001$, $\eta^2_{partial} = 0.18$), and distractor ($F[1,106] = 58.91$, $p < 0.001$, $\eta^2_{partial} = 0.36$). Interactions emerged between confidence and valence ($F[1,106] = 76.82$, $p < 0.001$, $\eta^2_{partial} =0.42$) as well as between confidence and distractor ($F[1,106] = 11.25$, $p = 0.001$, $\eta^2_{partial} = 0.10$). The three-way interaction failed to reach significance ($F[1,106] = 3.64$, $p = 0.06$, $\eta^2_{partial} = 0.03$). Results are illustrated in **Figure 12**. The two significant interactions are further illustrated in **Figure 13**.

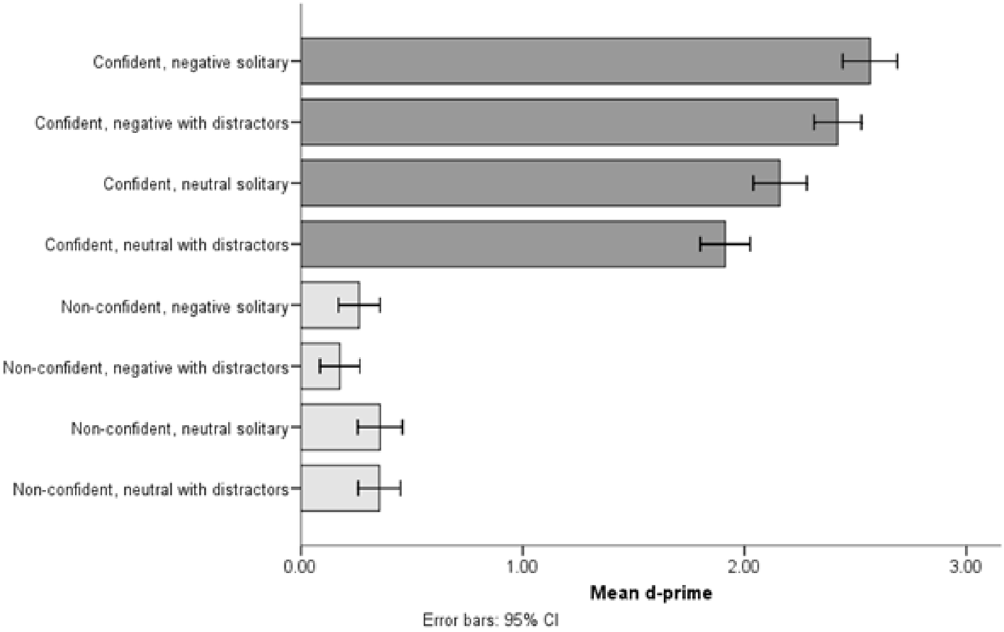


Figure 12. Mean recognition sensitivity (d-prime) for pictures from all eight conditions.

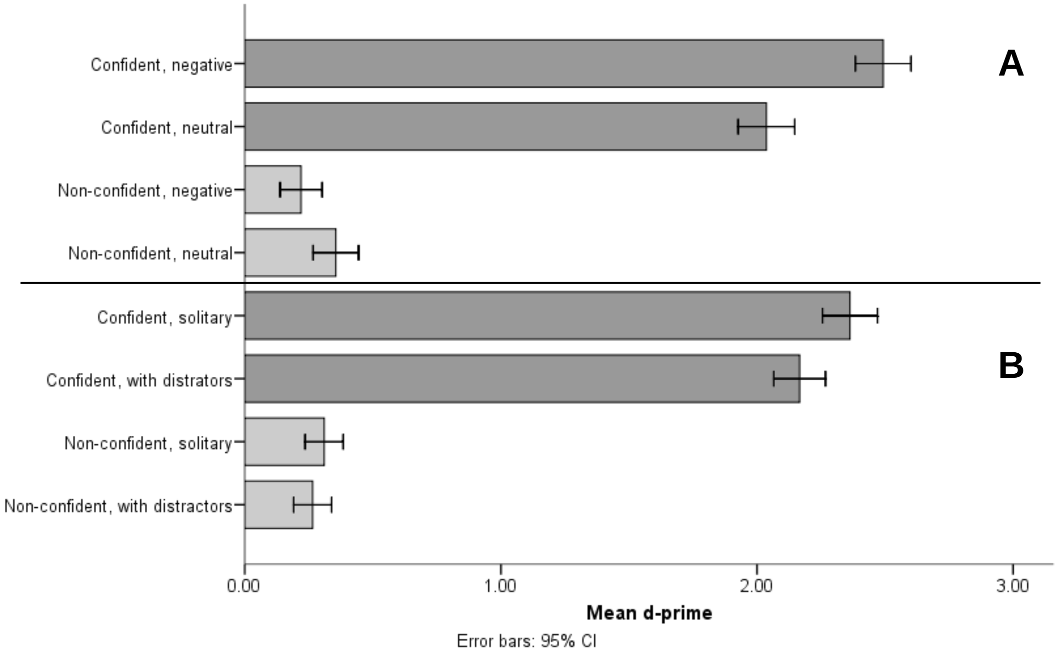


Figure 13. Mean recognition sensitivity (d-prime). **A**: Illustration of the confidence by valence interaction. **B**: Illustration of the confidence by distractor interaction.

The interaction between confidence and valence **(Figure 13A)** was driven by higher d-prime for confidently recognized negative than neutral pictures ($t[106] = 10.33$, $p < 0.001$), whereas d-prime was higher for non-confidently recognized neutral than negative pictures ($t[106] = -2.68$, $p < 0.05$, Bonferroni-corrected). The second interaction, between confidence and distractor **(Figure 13 B)** was driven by a lack of difference in d-prime between distractor conditions when recognition judgements were non-confident ($t[106] = 1.64$, $p = 0.10$), whereas for confident recognition, pictures without distractors had higher d-prime than pictures with distractors ($t[106]= 7.13$, $p < 0.01$, Bonferroni-corrected). Taken together, the confident recognition judgements showed the pattern I expected: Enhanced confident recognition sensitivity for negative than neutral pictures and for solitary pictures compared to pictures that had been presented with distractors.

To investigate participants' degree of liberal (tendency to respond "old" to all pictures) or conservative (tendency to respond "new" to all pictures) recognition bias, β-scores were analyzed. As these were highly skewed, a non-parametric Friedman test was performed including all eight β-scores (see **Figure 14**).

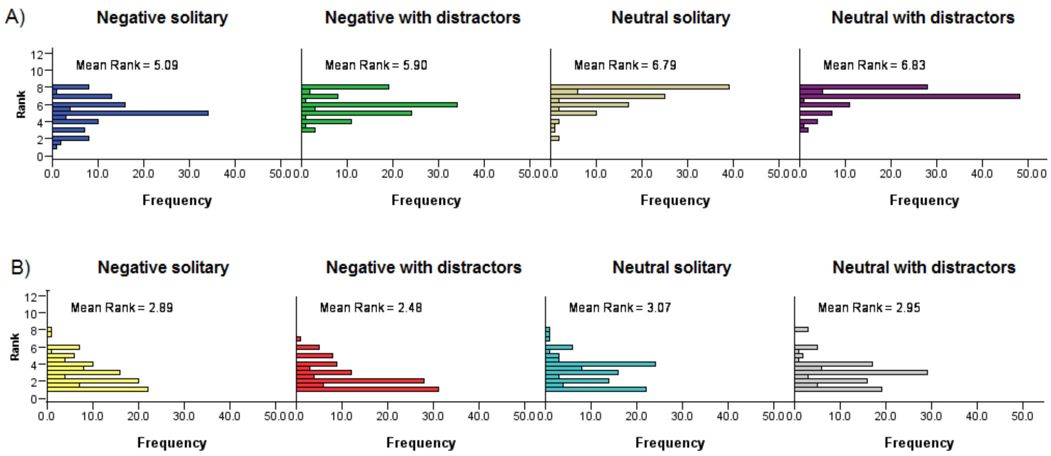


Figure 14. Mean ranks of response bias scores (β) for confident (A) and non-confident (B) recognition memory. Higher β-scores indicate a more conservative response bias (i.e.: tendency to respond "new" to all pictures, resulting in fewer hits but also fewer false alarms).

The Friedman test showed highly significant differences in response bias across all eight conditions ($\chi^2[7] = 432.12$, $p < 0.001$). Correcting for all pairwise comparisons, post-hoc tests on differences between average ranks showed more liberal response bias scores (lower ranks) in all non-confident compared to confident recognition judgments (smallest $T+ = 6.06$, all p's <0.001). Within either confident or non-confident recognition judgments, the only significant differences in bias scores were observed for confident recognition of negative solitary pictures. Bias scores for confident recognition were significantly more liberal for negative solitary pictures compared to both neutral picture conditions (neutral solitary: $T+ = 5.07$, $p < 0.001$; neutral with distractors: $T+ = 5.18$, $p < 0.001$), while not different from bias scores to negative pictures with distractors ($T+ = 2.4$, $p = 0.46$). This means that participants were more likely to choose "recognized" over "not recognized" when making non-confident choices. Additionally a greater bias to endorse negative pictures as "old" compared to the two neutral picture conditions, regardless whether they were correct or not, and this bias was most pronounced for negative solitary pictures.

3.1.5 Subsequent Memory Effect

I further predicted that viewing times of pictures during encoding will be predictive of later recall/recognition, i.e., an eye-tracking-based subsequent memory effect. I also predicted that subsequent memory effects will be stronger for negative than neutral pictures. Additionally, having distractors present at encoding had generally decreased viewing duration of pictures and had increased viewing duration of screen locations outside the pictures. I asked whether the presence/absence of distractors also modulated the size of the subsequent memory effect. As a reminder, subsequent memory effects were calculated by subtracting viewing durations of pictures (during encoding) that were later forgotten in free recall/recognition from viewing durations of pictures that were later recalled/recognized.

Subsequent memory effects emerged in free recall (*M* = 299.20 ± 423.76 msec; t-test against zero: *t*[106] = 7.3, $p < 0.001$) and confident recognition (*M* = 481.21 ± 377.06 msec; *t*[106] = 13.2, $p < 0.001$), but not in non-confident recognition (*M* = 57.17 ± 533.01 msec; *t*[103][6] = 1.09, $p = 0.28$). As can be seen in **Figure 15**, all three subsequent memory effects differed from each other in size (confident recognition > free recall > non-confident recognition, p's < 0.001).

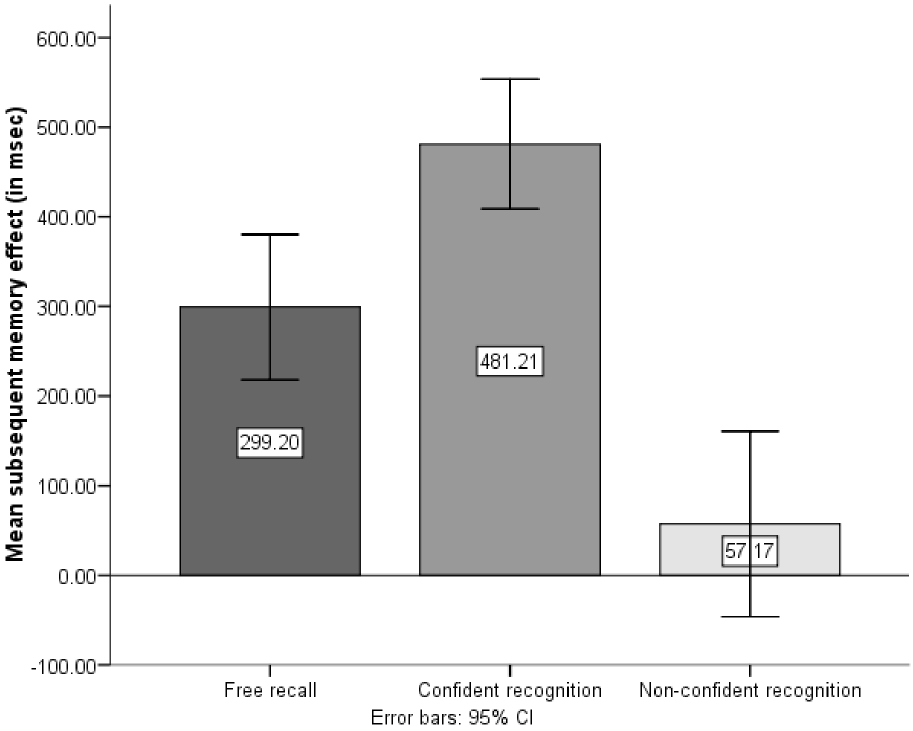


Figure 15. Mean subsequent memory effect (viewing duration of later memorised minus later forgotten pictures) for free recall, confident recognition and non-confident recognition (N = 107 in free recall/confident recognition; N= 104 in non-confident recognition).

As the subsequent memory effect for non-confident recognition was negligible, repeated measures ANOVA were only conducted on the size of the subsequent memory effects in free recall and in confident recognition, again with valence (negative/neutral) and distractor (solitary picture/ picture with distractors) as factors. Free recall data was missing in at least one of the four combinations of

---

[6] Three participants had zero non-confident recognition judgments precluding calculation of their SME.

the two factors for 36 participants. For confident recognition, data was missing in 6 participants. This left 71 participants for the ANOVA on subsequent memory effects in free recall and 101 participants for the ANOVA on confident recognition as a function of valence and distractor.

In free recall I found a main effect of distractor ($F[1,70] = 6.31$, $p = 0.01$, $\eta^2_{\text{partial}} = 0.08$) only, but neither main effect of valence ($F[1,70] = 0.32$, $p = 0.57$, $\eta^2_{\text{partial}} = 0.005$) nor an interaction between valence and distractor ($F[1,70] = 0.003$, $p = 0.96$, $\eta^2_{\text{partial}} < 0.001$). The subsequent memory effect was larger in trials with distractors ($M = 413.33 \pm 333.35$ msec) than in trials without distractors ($M = 206.32 \pm 610.97$ msec; see **Figure 16**).

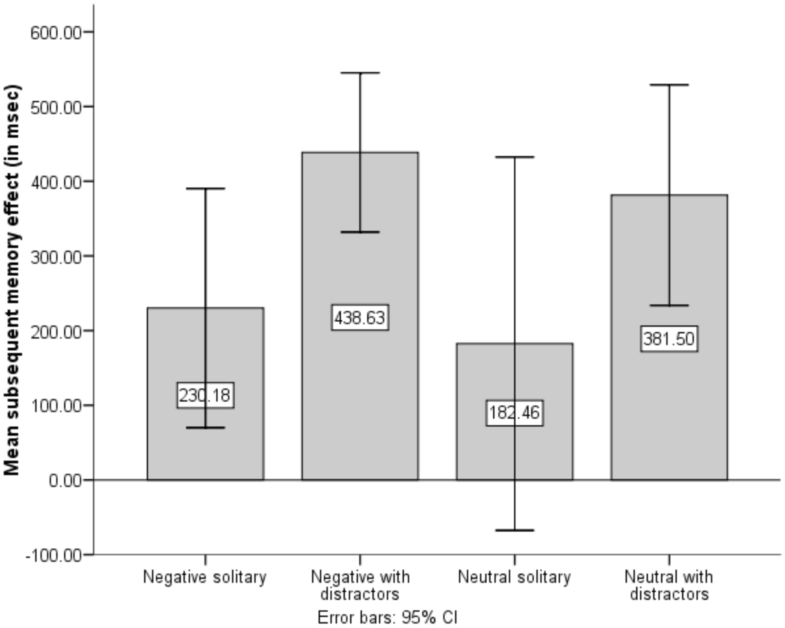


Figure 16. Mean subsequent memory effect for free recall (viewing duration of later confidently recognised minus later forgotten pictures) by valence and distractor (N = 71).

In confident recognition, I found main effects of valence ($F[1,100] = 9.69$, $p = 0.002$, $\eta^2_{\text{partial}} = 0.9$) and distractor ($F[1,100]= 11.25$, $p = 0.001$, $\eta^2_{\text{partial}} = 0.1$) but no interaction ($F[1,100] = 1.55$, $p = 0.26$, $\eta^2_{\text{partial}} = 0.02$). Similar as in free recall, the subsequent memory effect was larger in trials with distractors ($M =$

542.04 ± 341.23 msec) than in trials without distractors (*M* = 366.45 ± 527.08 msec). In addition, the subsequent memory effect was larger for negative (*M* = 526.5 ± 437.31 msec) than neutral picture trials (*M* = 381.99 ± 416.48 msec; see **Figure 17**).

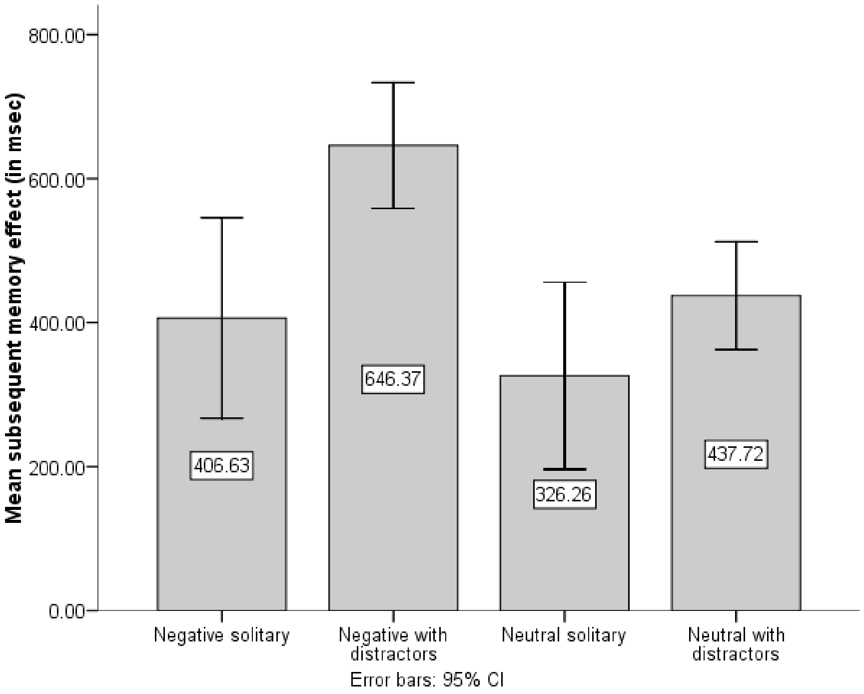


Figure 17. Mean subsequent memory effect for confident recognition (viewing duration of later recognized minus later forgotten pictures) by valence and distractor (N= 101).

The subsequent memory results should be understood in the context of the eye-tracking results during encoding (cf. section *3.1.2*), where I found a substantial decrease of picture viewing durations when distractors were present (versus absent). The most consistent subsequent memory results for both free recall and (confident) recognition was a main effect of distractor. Of note, the subsequent memory effect was also larger for pictures with negative compared to neutral valence, in confident recognition only; although the interaction was not significant ($F[1,100] = 1.55$, $p = 0.26$, $\eta^2_{\text{partial}} = 0.02$) and therefore not further followed up, **Figure 17** shows that this was mainly due to negative distractor trials. That is, looking at negative pictures *despite* the presence of distractors was most predictive of later memory. These results confirm that viewing durations in the encoding task do affect later memory, especially for pictures accompanied by distractors and, less pronouncedly so, in particular for negative pictures.

Taken together, hypothesis 1 was largely confirmed: I found that both the valence of the pictures and the presence of distractor images to affect not only response time to the encoding task but also the viewing duration. The presence of distractor items did not decrease viewing times of negative pictures to the same extent as it decreased viewing times of neutral pictures. Participants recalled more negative compared to neutral pictures regardless of distractor condition and in addition, recognition sensitivity (d-prime) was enhanced for negative compared to neutral pictures. That is, I found effects of emotional enhancement of memory. Recognition sensitivity was further higher for solitary compared to pictures that had been presented with distractors. Recognition biases (β) were more liberal for non-confident than confident choices regardless of valence or distractor. In confident recognition, negative solitary pictures were responded to more liberally, compared to neutral pictures. Thus, participants were more likely to indicate that they remembered a picture if it was negative, especially if presented alone, regardless whether their response was correct or incorrect.

The next sections are concerned with hypotheses 2 and 3, pertaining to repressive coping style.

3.2 Autonomic Response Discrepancy (ARD)

My second hypothesis predicted that participants pre-selected as repressors on the BIDR-SDE and STAI-T questionnaires will score highest on the index of autonomic response discrepancy (ARD). A positive ARD score indicates post-stress under-reporting of physiological stress during the stress task. The task elicited a sizable stress response from participants, as can be seen in **Figure 18**. A repeated measures ANOVA on SCL (amplitude) as a function of ‘time’ (in 10-second bins) and ‘group’ (repressor, low-anxious, high-anxious) showed a highly significant main effect of time (*F*[3.013, 301.3], Greenhouse-Geisser corrected =

120.13, $p < 0.001$, $\eta^2_{\text{partial}} = 0.55$), but the time by group interaction was not significant ($F[6.03,3.013] = 1.14$, $p = 0.34$, $\eta^2_{\text{partial}} = 0.02$).

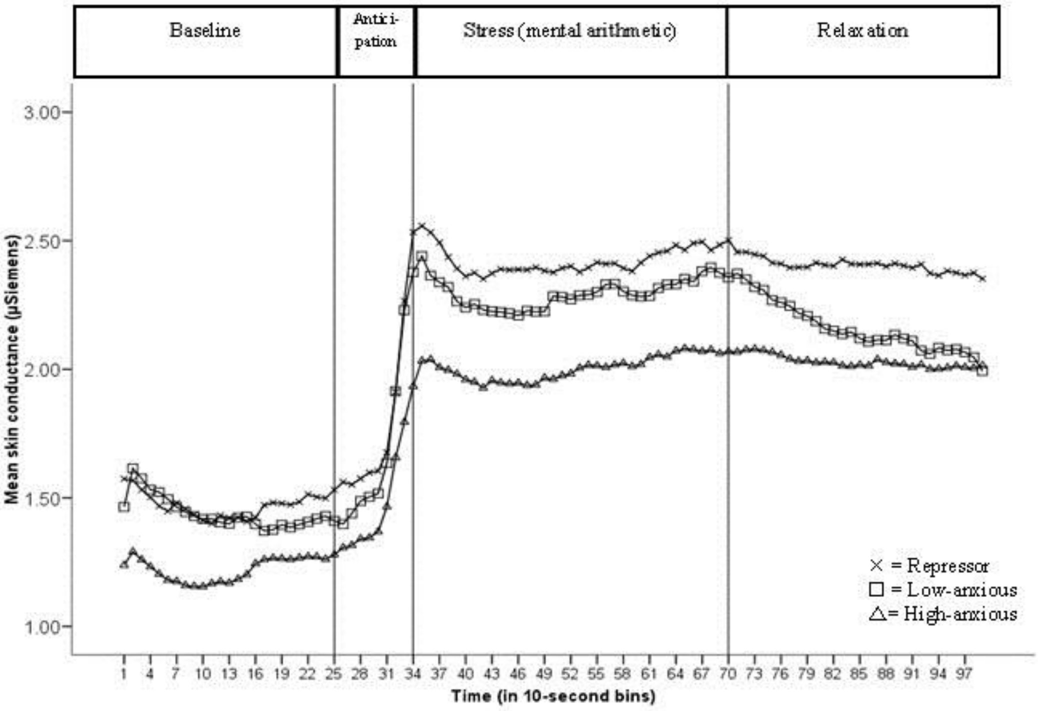


Figure 18. Skin conductance levels before, during and after the stress task.

Based on previous studies (e.g., Weinberger et al., 1979), I had expected the repressor group to show a greater increase in SCL at least compared to low-anxious individuals. However, groups in my study had similar SCL responses to the stress-induction and alternative attempts of analyzing these data (e.g., by assessing average slopes within each task phase across groups) did not render significant interactions with group either. Qualitatively inspecting **Figure 18** shows that the repressor group had a steep SCL increase during stress, with no recovery in the relaxation period. High anxious participants started out with a lower SCL during baseline, lower amplitude SCL during the stress task and they also showed no recovery during the relaxation phase. Low anxious participants' SCL levels appeared most similar to those of repressors, but the former showed some recovery of SCL during the relaxation phase. Thus, phrased differently, I was able to ascertain equivalent responsiveness of SCL to the stress induction task across groups.

Performance in the visual analogue scale (VAS) assessing mood across four positive and five negative emotions before and after the stress task is illustrated in **Figure 19**.

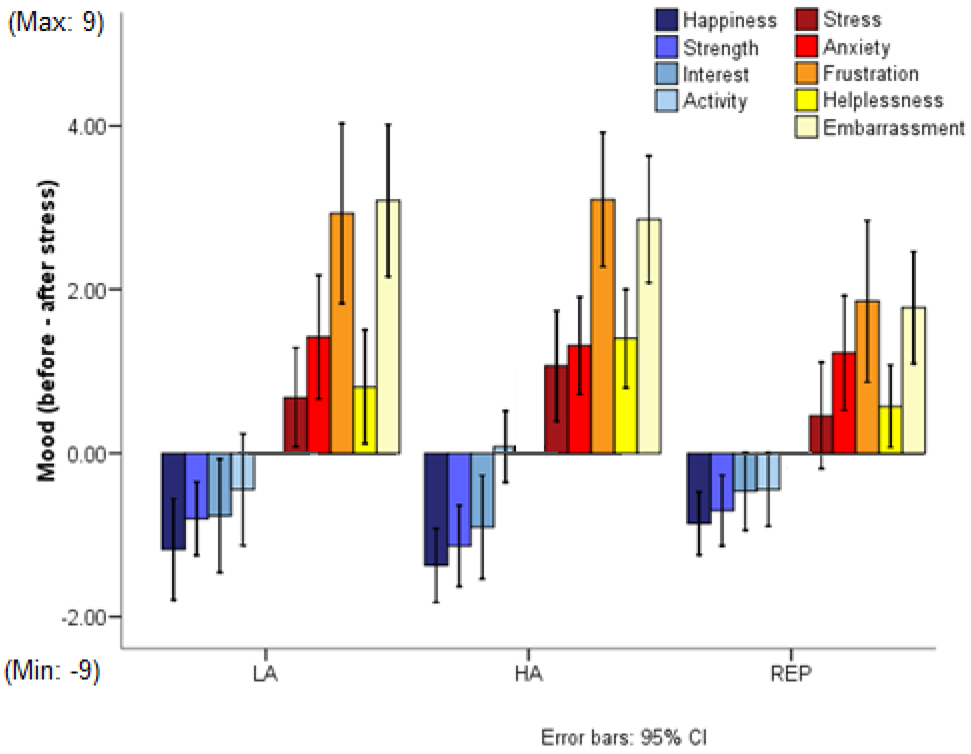


Figure 19. Difference scores in mood rating before and after the stress task.

The composite difference score in mood ratings before and after the stress task showed that groups marginally differed in their increase in negative mood after stress (*F*[2,104] = 2.57, *p* = 0.08), with repressors showing the least increase (*M* = 1.18 ± 1.4) in negative mood and high anxious individuals showing the most increase (*M* = 1.95 ± 1.68).

The ARD score was calculated next based on normalized (z-transformed on the sample’s average) change in skin conductance level from baseline to stress and change in self-rated mood before and after stress. The ARD was significantly different between groups, (*F*[2,106] = 4.55, *p* = 0.013). Repressors had a significantly higher ARD than high-anxious individuals (*t*[77] = 3.19, *p* = 0.01, Bonferroni-corrected; see **Figure 20**).

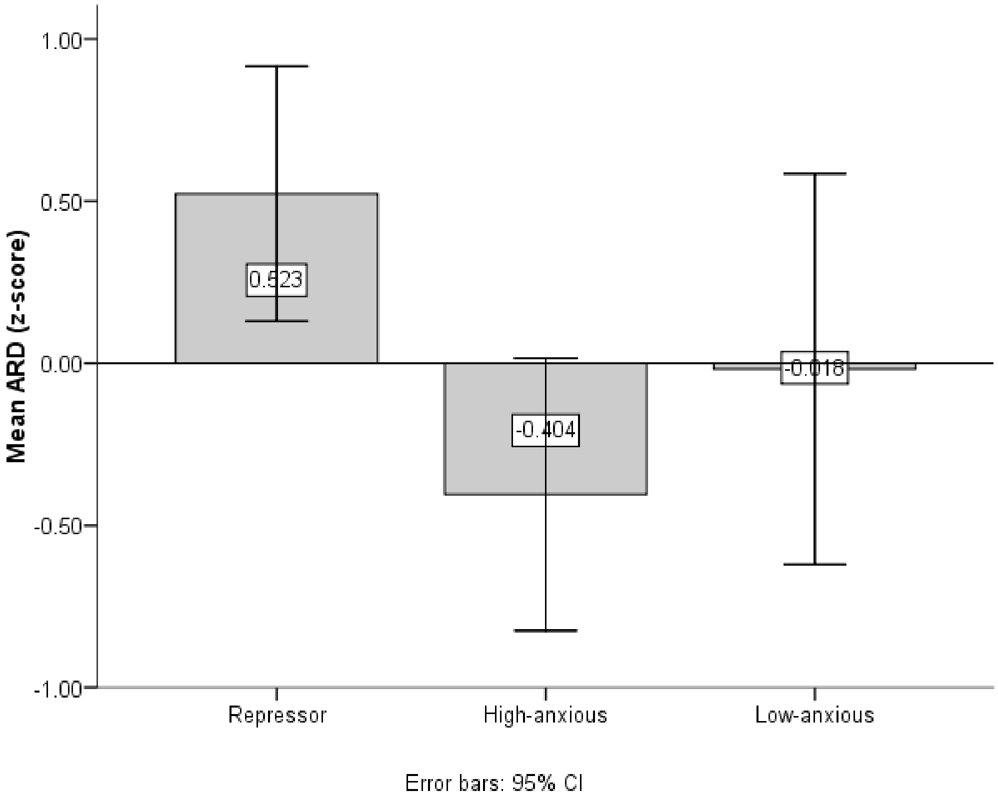


Figure 20. Mean autonomic-response dissociation (ARD) scores by coping style group, z-scores.

Repressors' ARD score was significantly larger than zero (*t*[34] = 2.7, *p* = 0.011), high-anxious individuals' ARD score showed a trend in the negative direction (*t*[43] = -1.94, *p* = 0.06), and low-anxious participants' ARD score was not different from zero (*t*[27] = -0.06, *p* = 0.95). Since the coping style groups did not differ in SCL during the stress-induction task here, the high ARD score specific to repressors was driven more so by under-reporting of emotional stress (VAS) than high physiological arousal (SCL). That is, normalized to the group's average ARD score, repressors showed a bias towards under-reporting physiological stress and differed significantly from high-anxious individuals who showed a trend in the opposite direction (relative over-reporting of physiological stress). These results confirm hypothesis 2.

3.3 Correlations Between ARD and Task Performance

The ARD was then correlated with different aspects of my task. I predicted in hypothesis 3, based on the Vigilance-Avoidance Theory, that a high ARD (repressive coping) would be negatively correlated with viewing durations of negative pictures, particularly when presented with distractors (attentional avoidance) but also negatively correlated with the time-point of first picture fixation (vigilance). I also predicted that ARD would positively correlate with viewing duration of non-picture areas on screen in negative picture trials (avoidance). Furthermore, I predicted that a high ARD would be correlated with low memory (free recall and/or recognition) of negative but not neutral pictures, again, especially when presented with distractors. To emphasize here, to my knowledge this is the first study assessing the potential links between repressive coping style-specific vigilance-avoidance patterns in attention with later memory performance within the same paradigm. Thus, exploratory analyses were conducted concerning the direct relationships between attention and memory by correlating the ARD with the size of the eye-tracking-based subsequent memory effects.

3.3.1 Attention

There were no significant correlations between ARD and response time during encoding. As detailed in **Table 5**, ARD was a) positively correlated with viewing durations of all pictures, irrespective of valence or distractor presence, b) negatively correlated with time-point of first picture fixation and c) negatively correlated with view time of screen locations outside pictures.

Table 5. *Correlations between encoding and autonomic-response dissociation (ARD), increase in skin conductance level (z-SCL), increase in negative mood in the visual analogue scale (z-VAS)*

	Negative Solitary	**Negative with Distractors**	**Neutral Solitary**	**Neutral with Distractors**
		Picture viewing duration		
ARD	0.34*	0.35*	0.36*	0.36*
z-SCL change	0.37*	0.38*	0.39*	0.37*
z-VAS mood	-0.11	-0.11	-0.12	-0.13
		Viewing duration of non-picture screen locations		
ARD	-0.25*	-0.20†	-0.24†	-0.16
z-SCL change	-0.27*	-0.21†	-0.23†	-0.13
z-VAS mood	0.09	0.07	0.11	0.09
		Time-point of first picture fixation (inverse-transformed)		
ARD	-0.21†	-0.22†	-0.18	-0.21†
z-SCL change	-0.23†	-0.28*	-0.23†	0.22†
z-VAS mood	0.07	0.03	0.03	0.07

* Bonferroni-corrected $p < 0.0125$; †: $p < 0.05$, uncorrected

Thus, I could not confirm hypothesis 3a that ARD would co-vary with attentional vigilance - avoidance patterns towards negative pictures in this task. In fact, high ARD scores were correlated with *longer* viewing durations of all pictures, and with *less* non-picture viewing, especially in trials with negative solitary pictures. In addition, I found earlier fixations (vigilance) in people with high ARD. The pattern was similar in all types of pictures, although the only significant correlation was seen for negative pictures with distractors. Breaking down the ARD score into its components showed that correlations were driven by changes in skin conductance levels, and not the self-reported mood changes. **Figure 21** shows that the correlation between picture viewing time and ARD was unlikely driven by outliers.

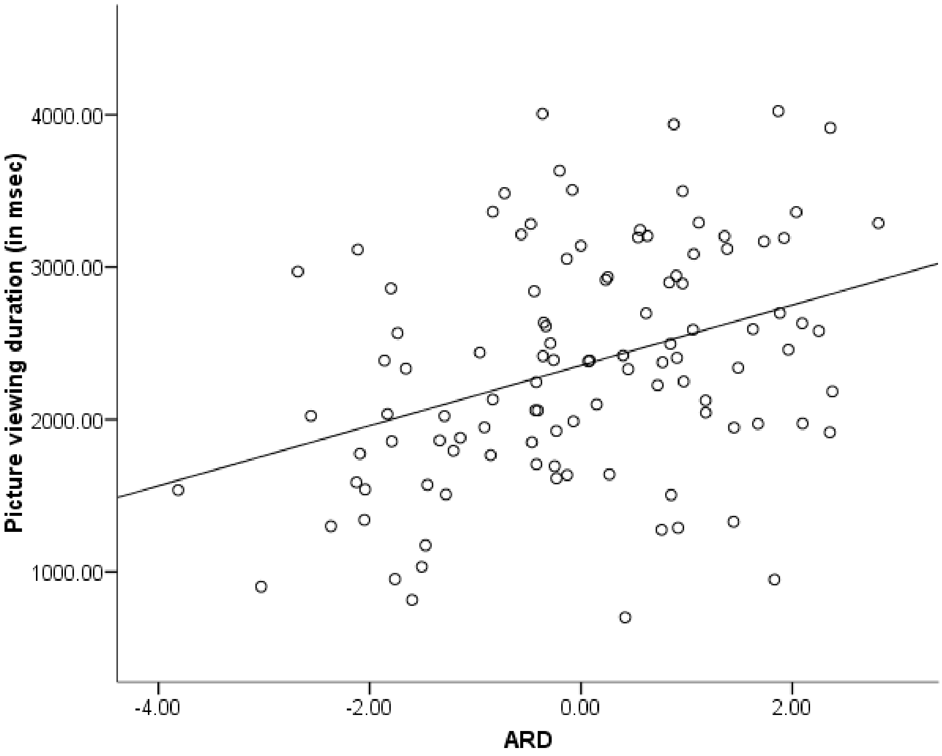


Figure 21. Correlation between picture viewing time and autonomic-response dissociation (ARD) ($r[105] = 0.36$, $p < 0.001$, all picture conditions are combined).

Taken together, participants with higher ARD scores were vigilant to all picture stimuli in this task and did not show the predicted attentional avoidance of negative pictures. These correlations were driven by the SCL and not the mood component of the ARD.

3.3.2 Memory

I expected free recall and/or recognition memory for negative pictures to be negatively correlated with ARD, but expected no correlation with memory for neutral pictures. The correlation results are summarized in **Table 6**.

Table 6. *Correlations between free recall proportions/recognition sensitivity (d-prime) and autonomic-response dissociation (ARD), increase in skin conductance level (z-SCL), increase in negative mood in the visual analogue scale (z-VAS)*

	Negative Solitary	**Negative with Distractors**	**Neutral Solitary**	**Neutral with Distractors**
Free recall [a]				
ARD	0.04	-0.05	0.05	0.05
z-SCL change	-0.07	-0.03	0.02	0.03
z-VAS mood	-0.10	-0.04	-0.04	-0.07
d-prime (confident recognition)				
ARD	-0.07	0.02	0.10	0.06
z-SCL change	-0.03	-0.08	-0.04	-0.06
z-VAS mood	0.07	-0.05	-0.17	-0.15
d-prime (non-confident recognition)				
ARD	-0.04	-0.12	-0.13	-0.15
z-SCL change	-0.04	0.01	-0.02	-0.10
z-VAS mood	0.02	0.18	0.17	0.13
β (confident recognition) [a]				
ARD	-0.19†	-0.28*	-0.13	-0.10
z-SCL change	-0.17	-0.23†	-0.18	-0.15
z-VAS mood	0.11	0.19†	0.05	0.004
β (non-confident recognition) [a]				
ARD	-0.05	-0.11	-0.08	-0.12
z-SCL change	-0.03	-0.06	0.03	-0.07
z-VAS mood	0.08	0.13	0.13	0.09

[a]: Spearman rank correlations; *: Bonferroni-corrected, $p] < 0.0125$; †: $p < 0.05$, uncorrected

There were no significant correlations between ARD and memory accuracy in either free recall or recognition (d-prime), with relationships mostly being close to zero. As can be seen in **Table 6**, correlations emerged only in response bias (β), for confident recognition judgements. Individuals with high ARD scores seemed to have a more liberal[7] response bias in making confident judgements, a trend that reached significance for negative pictures with distractors. This means that increasing ARD is indicative of a greater chance that

---

[7] High β-scores indicate a conservative bias and low scores indicate liberal response bias.

the participant will claim they confidently recognize a picture, regardless if correct or not.

To disentangle these results, I conducted several follow-up analyses. First, as only the β-scores showed any noticeable correlations with ARD and since all of these were similar to each other, I averaged β across all four picture conditions. ARD was correlated with a liberal bias for confident responses ($r[105] = -0.28$, $p = 0.003$). This correlation was reflected in both components of the ARD (SCL change: $r[105] = -0.20$, $p = 0.04$; VAS negative mood: $r[105] = 0.19$, $p = 0.046$). Thus, individuals with high ARD made more confident recognition judgments, regardless whether these were correct or incorrect. In addition, I correlated ARD and its components with the simple hit rates and false alarm rates subsumed in d-prime and β, only for confident recognition hits/false alarms. These results are shown in **Table 7**.

Table 7. *Correlations between recognition hit/false alarm rates and autonomic-response dissociation (ARD), increase in skin conductance level (z-SCL), increase in negative mood in the visual analogue scale (z-VAS)*

	Negative Solitary	**Negative with Distractors**	**Neutral Solitary**	**Neutral with Distractors**
		Confident hit rate		
ARD	0.06	0.14	0.22†	0.20†
z-SCL change	0.05	0.02	0.04	0.03
z-VAS mood	-0.03	-0.18	-0.27*	-0.24†

	Negative Targets	**Neutral Targets**
	Confident hit rate	
ARD	0.10	0.22†
z-SCL change	0.04	0.04
z-VAS mood	-0.11	-0.28*

	Negative Lures	**Neutral Lures**
	Confident false alarm rate [a]	
ARD	0.19†	0.10
z-SCL change	0.14	0.13
z-VAS mood	-0.13	-0.06

[a]: Spearman rank correlations, * Bonferroni-corrected $p < 0.0125$; †: $p < 0.05$, uncorrected;

As can be seen in **Table 7**, by breaking down the constituents of d-prime/β, I found that ARD showed a positive trend correlation (and VAS showed a significant negative correlation) with hit rates for all neutral pictures from the encoding task (target pictures), but non-significant (albeit still positive) correlations with hit rates for all negative target pictures. Conversely, false alarms rates for negative lure pictures showed a positive trend correlation with ARD, which was not seen for neutral lures.

In addition to recall/recognition accuracy, I then tested whether the advantage of memory for negative pictures over neutral pictures was correlated with ARD. As outlined in the Methods section, the EEM scores were calculated only for free recall and confident recognition. The EEM score in free recall rendered only non-significant correlations with ARD and will not be discussed further. The composite EEM in confident recognition (EEM_{RECOG}) was correlated with ARD, z-SCL change and z-VAS mood. The results showed a significant negative correlations between EEM_{RECOG} and ARD ($r[105] = -0.20$, $p = 0.04$). This correlation was reflected only in the mood component of the ARD (VAS negative mood: $r[105] = 0.24$, $p = 0.012$), but not in the SCL change ($r[105] = -0.04$, $p = 0.66$). Thus, even though ARD or its components were largely unrelated to memory accuracy, the *differential* enhancement of confident recognition memory of negative compared to neutral pictures, adjusted for false alarms rates, was less pronounced with higher ARD and more pronounced with more self-reported negative mood.

To further test whether the correlations I observed between the ARD/VAS and the EEM were present in both solitary and distractor trials, the EEM was broken down into $EEM_{solitary}$ and $EEM_{distractor}$ conditions, as detailed in the Methods section and correlated with ARD, z-SCL change and z-VAS mood. Results showed a significant negative correlation between the ARD and $EEM_{solitary}$ ($r[105] = -0.21$, $p = 0.03$), but not with $EEM_{distractor}$ ($r[105] = -0.15$, $p = 0.12$). As before, the correlation was reflected only in the mood component of the ARD (VAS negative mood: $r[105] = 0.29$, $p = 0.003$), but not in the SCL change ($r[105] = -0.002$, $p = 0.98$). Thus, the correlations between the ARD and the decrease in the emotional enhancement of confident recognition memory, as well as the inverse correlation with VAS reached significance only for solitary picture trials (see **Figure 22**).

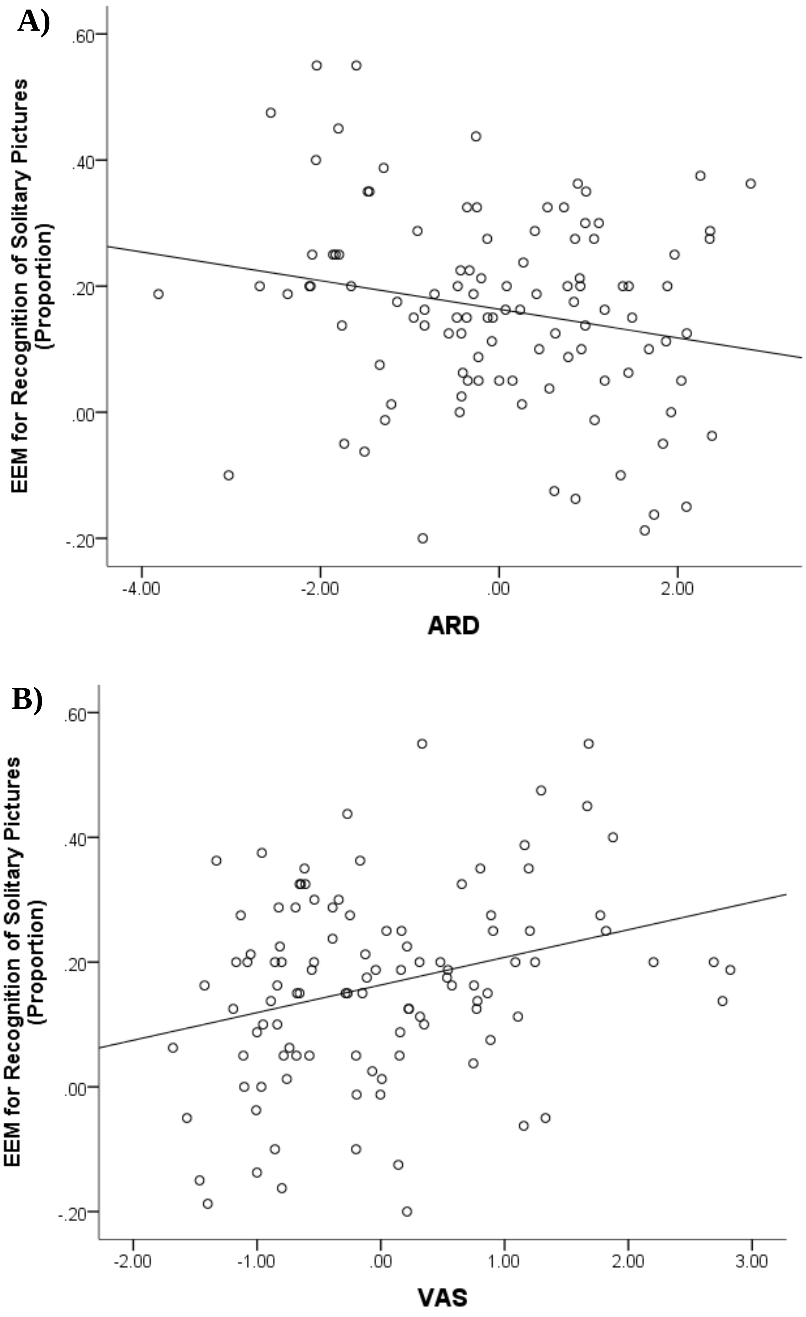


Figure 22. Correlations between the relative enhancement of confident recognition memory for negative solitary pictures minus neutral solitary pictures, adjusted for false alarms, and ARD (**A)** and VAS (**B**). (EEM: enhancement of

memory due to emotion; ARD: autonomic response dissociation; VAS: Visual analogue scale)

In summary, the results of the memory component of this study partly confirmed my predictions in hypothesis 3b. The ARD did not correlate negatively with recall accuracy or recognition quality of negative pictures. However, I found ARD correlated with a liberal response bias towards making confident recognition judgments. This bias appeared to be based on an increase in confident hits of neutral pictures and on an increase in confident false alarms towards negative lure pictures. In addition, a higher ARD was related to a less pronounced *relative* advantage for negative over neutral picture recognition, significant only for solitary picture trials. This was due to self-reported mood only. In other words, people with less self-reported negative mood after the stress task showed less of a difference in negative compared to neutral solitary picture recognition, while people with a more negative mood had a more pronounced advantage in negative over neutral solitary picture recognition.

3.3.3 Subsequent Memory Effect

As view time was quite substantially related to later free recall and confident recognition memory, I tested whether subsequent memory effects were correlated with ARD and its components. In brief, there were few significant correlations, but those that were found were selective to subsequent memory effects for negative solitary pictures (see **Appendix 4** for all correlations).

First, ARD was correlated with the subsequent memory effect for free recall of negative solitary pictures ($r[101] = 0.28$, $p = 0.004$), mainly due to the self-reported mood component of the ARD ($r[101] = 0.29$, $p = 0.003$) and not to changes in skin conductance levels ($r[101] = 0.1$, $p = 0.31$). All other correlations between ARD and subsequent memory effects in free recall were close to zero (see **Appendix 4**).

Subsequent memory effect for confident recognition of negative solitary pictures was not significantly correlated with overall ARD ($r[102] = 0.14$, $p = 0.15$) or its self-reported mood component ($r[102] = 0.03$, $p = 0.78$), but showed a positive correlation with changes in skin conductance levels ($r[102] = 0.23$, $p =$

0.02). Again, both ARD and its components showed near-zero correlations to subsequent memory effects of all other confidently recognized picture types.

Thus, individuals with higher ARD showed a selectively stronger link between viewing durations and later free recall of negative solitary pictures and this effect pertained mainly to self-reported mood. More pronounced changes in skin conductance levels during the stress task were associated with increased subsequent memory effects in confident recognition, again selectively for negative solitary pictures.

4. DISCUSSION

As predicted in hypothesis 1, I found prioritization of emotional over neutral pictures in both the attention and the memory part of my task. Participants spent more time looking at negative pictures than neutral pictures. Their visual attention to all pictures decreased when distractor images were present, but less so in negative than in neutral picture trials. Participants also had better memory for negative compared to neutral pictures, spanning free recall and (confident) recognition memory. A sizeable subsequent memory effect was observed for both, free recall and confident recognition and as predicted, the size of the subsequent memory effect was larger for negative than neutral pictures, although only in recognition memory.

Hypothesis 2 was also supported. Relative to the rest of the sample, participants classified through conventional questionnaires as having a repressive coping style demonstrated an autonomic response discrepancy (ARD) comprising a similar physiological response (SCL) as non-repressors in response to my stress induction task, accompanied by little self-reported negative mood change (VAS). When both SCL and VAS measures were combined to create the ARD score, repressive individuals had significantly higher ARD than high-anxious participants, who tended to over-report their negative mood changes. Low anxious individuals showed no ARD.

Hypothesis 3a was not supported by my results. I did not observe attentional vigilance-avoidance patterns towards negative pictures, assessed with eye-tracking. Instead, high ARD (repressive coping) was associated with longer view time to all pictures, regardless of valence. In addition, high ARD was correlated with earlier first fixation to all pictures. Nevertheless, in support of hypothesis 3b I found that high ARD was related to less emotional enhancement of recognition memory (EEM) for solitary pictures only. Thus, even though overall recall/recognition accuracy did not vary with ARD, the memory enhancing effects of negative solitary pictures, relative to neutral solitary pictures, diminished with increasing ARD.

Finally, I found a positive correlation between ARD and the size of the subsequent memory effect that was again specific to negative solitary pictures. In this particular condition, attention was more predictive of later memory as a function of high ARD (free recall) or as a function of high SCL (recognition).

4.1 Emotion-Cognition Interactions

Participants spent more time looking at negative than neutral pictures and their visual attention to the pictures decreased when the distractor images were present. This is congruent with emotional prioritization in attention spanning various paradigms and effects, including pop-out effects of emotional faces or pictures amongst neutral counterparts in visual search paradigms (Frischen, Eastwood, & Smilek, 2008; Lamy, Amunts, & Bar-Haim, 2008; Öhman et al., 2001), slowed response latencies towards emotional words than neutral words in emotional Stroop tasks (Egloff & Hock, 2003; McKenna & Sharma, 1995; Williams, Mathews, & MacLeod, 1996), faster orientation and/or slower disengagement of spatial selective attention in emotional dot-probe tasks (Amin & Canli, 2004; Koster, Crombez, Verschuere, & De Houwer, 2004; MacLeod & Mathews, 1988; Mather & Carstensen, 2005), and also more directly related to my measures, previous eye-tracking studies in which emotional pictures have attracted more visual attention than neutral pictures when presented simultaneously (Calvo & Lang, 2004; Nummenmaa et al., 2006).

The replication of such prioritization of emotional materials is reassuring and indicates that the negative pictures I used were salient enough to affect subjects' viewing patterns. While the presence of distractors significantly reduced the view time of both negative and neutral pictures, this reduction in view time was less pronounced in negative picture trials. Thus, the emotional image content *and* the presence/absence of visual distraction influenced the gaze patterns in my study. It should be emphasized that my task did not dictate selective (non-) attention of particular stimuli or screen locations, it never showed neutral and negative pictures simultaneously and it was cognitively non-demanding. Thus, effects of "distraction" on emotion-attention interactions in my study are not directly comparable to most previous results in which such distraction was achieved by other means. These included, for example, presenting emotionally distracting stimuli in conjunction with a primary task (or stimulus) and assessing residual performance (e.g., Chan & Singhal, 2013; Fenske & Eastwood, 2003; Zhou & Liu, 2013), or dividing participants' attention through a dual task setup and assessing their remaining capacity for processing emotional versus neutral materials (Allard & Isaacowitz, 2008; Kern, Libkuman, Otani, & Holmes, 2005). Nevertheless, in such studies, emotional distraction usually interferes more than non-emotional distraction with primary task performance, unless the emotional distractor bears task relevance (Egner, Etkin, Gale, & Hirsch, 2008; see also: Easterbrook, 1959). Complementary, processing of emotional stimuli is usually less affected by dual task paradigms than processing of neutral stimuli (Kern et al., 2005) implying that emotionally arousing information can be processed at least in part pre-attentively and with less conscious effort (A. K. Anderson, 2005). In free viewing paradigms, more similar to my task here, people show a preference to attend to salient information, including human faces, the eye-region of face pictures, or socially meaningful information (Farroni, Csibra, Simion, & Johnson, 2002; Guo, Tunnicliffe, & Roebuck, 2010; Masciocchi, Mihalas, Parkhurst, & Niebur, 2009). Thus, presenting simple scrambled visual distractor items in an (almost) free-viewing task likely enabled natural fixation preferences towards emotionally salient information and at the same time, rendered distractors less able to capture visual attention when competing with the more salient pictures.

Congruent with the attentional patterns at encoding, participants also had better later memory for negative compared to neutral pictures. In agreement with previous studies (e.g., Riggs, McQuiggan, Anderson, & Ryan, 2010; Sharot & Phelps, 2004; Talmi & McGarry, 2012; Talmi, Riggs, Caplan, & Moscovitch, 2008), the emotional enhancement of memory is thought to be at least partially due to the increased attention garnered by the emotional items during encoding. Since my study only assessed gaze patterns at encoding and did not investigate covert attention, my findings should be understood only in the realm of visual overt attention. Additional, covert or automatic attention processes are known to mediate emotional memory enhancement (Dolan & Vuilleumier, 2003), these were just not assessed here.

The size of the subsequent memory effect I observed based on the combination of the eye-tracking data with later memory success/failure was rather large with an almost 300 msec difference in free recall and 480 msec difference in (confident) recognition memory. The difference in the size of this effect between the free recall and confident recognition can largely be attributed to the different number of trials in free recall versus recognition memory that constituted remembered or forgotten trials. On average, people recalled only 17.97 (11.23%) of the pictures in free recall (and hence did not recall 142.03, 88.76% of the 160 pictures). In contrast, people had 99.2 confident hits (62%) in recognition memory and 60.8 misses (38%). Thus, the statistical sensitivity of comparing viewing durations during successful and unsuccessful encoding in free recall was reduced compared to recognition memory. It is indeed surprising that I observed a subsequent memory effect in free recall at all, given the extremely different numbers of recalled/not recalled pictures. To the best of my knowledge, no prior study *directly* examined subsequent memory effects via eye-tracking, which makes an evaluation of its absolute magnitude difficult. However, this method seemed quite robust (free recall: Cohen's $d[106] = 1.4$; recognition: $d[106] = 2.56$). The size of the subsequent memory effect in (confident) recognition memory was further modulated by picture valence, with larger effects for negative than for neutral pictures. I predicted this finding based on previous fMRI and EEG studies showing changes in topography, extent, and size of the emotional subsequent memory effect (Dolcos et al., 2004; Erk et al., 2003; Kensinger & Schacter, 2006; Richardson et al., 2004; Schwarze et al., 2012).

More importantly, this finding implies that attention was indeed a critical modulator of the increase in memory for emotional over neutral pictures, at least for (confident) recognition memory. Of note, a recent study by Kim, Vossel, and Gamer (2013) found a seemingly opposing result. They assessed relationships between visual attention (assessed with eye-tracking) and the central/peripheral memory trade-off. In short, this refers to memory enhancement for central information presented in a negative emotional context, while at the same time leading to memory impairment for peripheral information, based on Easterbrook (1959). Kim and others (2013) did observe this pattern of finding in recognition memory; however, they could show that this effect was not mediated by visual attention. Central information presented in a negative context did not need to be fixated early or long to be successfully recognised later, while peripheral information needed to be attended to longer to be recognised. My study differs from that of Kim and others (2013) in various ways, including in the analysis of the eye-tracking patterns. Perhaps most importantly, the screen quadrants in which the pictures in my task occurred were arguably all close to, but not directly in, the centre of the screen, without the intention to distinguish between central and peripheral screen locations. Since the size of the subsequent memory effect was more definitely modulated by the presence of distractors in my task, which increased the effect in both free recall and in recognition memory, one could argue in agreement with Kim and others's (2013) findings that attention becomes more important in mediating later memory whenever larger eye-movement have to be made.

The subsequent memory effect in free recall was uninfluenced by picture valence. Although this finding, together with the smaller size of the effect in free recall than recognition was likely due to statistical power, free recall might also require deeper, semantic encoding (Roediger & Challis, 1989) and could therefore be less influenced by mere visual attention at encoding than later recognition memory.

My first hypothesis (task validation) was largely confirmed, showing the expected prioritization of negative over neutral stimuli in attention and the resulting increase in later memory. My findings support the use of my paradigm as one that is able to test the general effects of emotion on attention and later memory. Therefore further investigation of how coping style mediates the effect of emotion on attention and memory can be achieved.

4.2 Individuals with a Repressive Coping Style Under-Report Physiological Stress

Using a stress induction task in conjunction with self-report mood scales, repressive individuals classified with conventional trait-anxiety and defensiveness questionnaires, similar to Weinberger et al. (1979), did not differ from low-anxious or high-anxious participants in skin conductance levels (SCL) during the stress task, but showed a trend effect towards reporting less negative mood changes in the visual analogue scale (VAS) than the high anxious participants after the stress task. The lack of higher physiological stress in the repressor group compared to high and low anxious was unexpected, but the combination of the two measures (used to create the autonomic response dissociation [ARD] score) revealed that repressors were the only group with a significant reporting bias indicating under-reporting of stress-induced changes in SCL. Their ARD was also significantly different from that of high anxious participants, who showed a trend in the opposite direction (i.e., over-reporting of negative mood in conjunction with relatively smaller stress-induced SCL elevations). These findings are consistent with previous research (e.g., Barger et al., 1997; Coifman et al., 2007; Newton & Contrada, 1992; Pauls & Stemmler, 2003) and confirm hypothesis 2. My findings support that repressors, relative to individuals with other stress coping styles, do not accurately report their physiological arousal levels in stressful situations.

The function of such ARD in repressors has been argued to represent a defensive mechanism aimed at avoiding the conscious experience of distress (Asendorpf & Scherer, 1983; Brosschot & Janssen, 1998; Gudjonsson, 1981; Pauls & Stemmler, 2003; Weinberger et al., 1979), especially with regard to personal or social threat (Derakshan et al., 2007; Newton & Contrada, 1992). Mental arithmetic tasks such as the one in the current study are thought to probe *psychosocial* stress, such as a type of stress resulting from situations that target important aspects of one’s self- and social image. A mental arithmetic task is part of the Trier Social Stress Test (Kirschbaum et al., 1993), the ‘gold’ standard for psychosocial stress induction. The perception of an evaluative audience, achieved in my experiment by the presence of and the continuous evaluative feedback from the experimenter, has previously been reported to result in heightened self-awareness and has been argued to increase the effects of social standards on self-perception and behaviour (Carver & Scheier, 1981).

My results cannot speak directly to potentially *separate* contributions of threat to one's self-image compared to one's social image and to the specific roles of either in repressive coping style. The question whether repressors are particularly sensitive towards social- compared to self-evaluative situations has been debated previously. For example, Baumeister and Cairns (1992) found that negative performance feedback delivered either in a social or a private setting led to increased reading time in repressors in social settings and decreased reading time in private settings. That is, the presence of a social evaluative context may have disabled repressors' natural defense to dismiss unwanted thoughts, and instead motivated them to dwell on potential embarrassment while they were able to avoid such when in private (see also Myers & Derakshan, 2004). Using self-report and heart-rate change measures, Newton and Contrada (1992) further found repressors to engage in autonomic-response dissociation only in experimental conditions with concurrent presence of others but not in private conditions, emphasizing a social determinant of ARD. However, Barger and others (1997) showed that situational contexts varying the public or private nature of the experimental setting, did *not* modulate repressors' ARD when using SCL as the physiological component of the ARD, compared to heart rate changes as done by Newton and Contrada (1992). That is, Barger and colleagues' (1997) findings suggest that repressors' ARD is elicited regardless of the nature of the setting, at least when SCL measures are used. Heart rate changes indicate a shorter-lasting sympathetic arousal response triggering motivational, appetitive approach behaviour (e.g. Fowles, Fisher, & Tranel, 1982; Tranel, 1983). Skin conductance is understood as part of an system that responds to aversive situations and is sensitive to behavioral inhibition in the face of threat (Fowles, 1980). Thus, it can be argued that using SCL to specifically assess the automatically triggered, avoidant aspect of repressive coping is a more appropriate measure than heart rate changes (Barger et al., 1997), a reason why SCL was used here.

Another possible reason for the observed discrepancies in private/public determinants of ARD in repressive individuals is the use of different defensiveness measures across studies. The most commonly employed scale, the MC-SDS (Crowne & Marlowe, 1964), consists of both, items measuring inward-directed, exaggerated perceptions of grandiosity and items measuring publicly observable aspects of socially desirable behaviours. That is, depending on which particular items (i.e., those of a more private versus those of a more public nature) *within* the MC-SDS were endorsed by the respective groups of repressors across studies, repressors' sensitivity (i.e., their ARD) to the different situational contexts may differ, something that was not addressed within these studies. To avoid this ambiguity at least on the level of the defensiveness dimension of repressive coping style, I used the BIDR-SDE (Paulhus, 1991) which explicitly targets the inward-directed dimension of defensiveness (i.e., self- rather than other-deception) which is thought to be more closely related to the conceptual definition of repressive coping as a relatively unconscious defense mechanism that is automatically exhibited (Derakshan, 1999; Weinberger, 1990; Weinberger & Davidson, 1994). Nevertheless, as mentioned above, my paradigm did not separate situational contexts and although this separation is indeed inherently difficult to achieve with ego-threat manipulations (Leary, Terry, Allen, & Tate, 2009), this remains an open question for future studies.

Regardless whether elicited automatically in all situations or only in certain situations, the implications of a stress coping style where subjectively acknowledged distress and physiological arousal are dissociated, is wide-ranging. For example, findings from health psychology have shown that repressive coping style might lead to an elevated likelihood of certain physical illnesses, including cardiovascular diseases and cancer (Mund & Mitte, 2012). Myers (2010) proposes the idea that repressors may be negligent towards their physical self-care, to the extent of compromising their health, at least when they feel not in control of such health-behaviours. An interesting possibility in this regard is that repressors might have a dissociation between acknowledging physical pain compared to emotional distress. For example, Burns and others (2010) induced pain (thermal pain with a cold pressor test, ischemic pain with an arm cuff) and tested participants' ratings of their emotional distress and physical pain severity during and after the pain induction. Repressors, relative to other coping style groups, *over*-reported physical pain experience but *under*-reported emotional distress, a pattern that was argued to resemble a 'conversion'-like process (that is, re-interpretation of emotional distress into somatic symptoms). This 'conversion' process was further argued to be achieved by diverting attentional allocation away from emotional distress and towards sensory pain: In a dot-probe task after pain induction, repressors in Burns and others (2010) showed an attentional bias towards pain words, and away from emotional distress words. .

In summary, I could confirm – in agreement to my second hypothesis – that repressors selected based on low self-reported trait anxiety and high levels of self-deceptive enhancement substantially under-report their experienced levels of stress during a psychosocial stress task. As a note of caution, one should still keep in mind that changes in SCL and mood were relative scores. That is, even though the arbitrary qualities of typological cut-off scores to distinguish groups were avoided by way of using a continuous ARD score instead, it still is a relative score that depends on the average ARD of the tested participants (and not the entire 'population'). Nevertheless, finding high anxious individuals at the bottom and repressors at the top end of the ARD was encouraging and enabled the use of the ARD for the further analyses and test of hypothesis 3.

4.3 Attention as a Function of Autonomic-Response Dissociation

The ARD was positively correlated with picture viewing time, negatively correlated with the time of first picture fixation and viewing time of distractors, regardless of the emotional valence of the pictures. These findings are in opposition to my hypothesis 3a, which suggested that high ARD would be associated with earlier fixations to negative pictures specifically and with a shorter view time of negative pictures, especially if accompanied by distractors.

In general, under stress (selective) attention becomes focused on task-relevant information at the expense of task-irrelevant information (Chajut & Algom, 2003, Easterbrook, 1959). Although the participants generally showed a preference in viewing emotional compared to neutral pictures, the task potentially rendered all stimuli ‘relevant’ insofar as they all were supposed to be counted I also did not ask to selectively focus on (or ignore) certain types of pictures. It is therefore possible that individuals with a more pronounced physiological reaction to stressful situations (i.e., those with high ARD) were particularly focused and attentive to all pictures. In support of this interpretation, the physiological (SCL) component of the ARD, but not self-reported mood drove the positive correlations between ARD and viewing patterns. Although the results are correlational, physiological stress levels might have led to the increased task focus, indicated by visual attention. This is especially likely as the encoding task occurred immediately after the stress task. That is, physiological consequences of stress induction, also including stress hormones like cortisol, although not measured here, peaks in concentration at about 20 minute after initiation of similar psychosocial stress tasks. Therefore, if triggered in my experiment, stress (cortisol) may have had maximum levels during the encoding task (for a more detailed description of the time-course of stress-induced cortisol increases see Wolf, 2008).

Earlier attention to picture stimuli as a function of high ARD, regardless of valence here, may still imply a repressor-specific attentional vigilance mechanism as proposed in previous studies, with a function of enhancing the probability to detect threats in the environment (Derakshan et al., 2007; Hock & Egloff, 1998; Kline et al., 1998; Mogg et al., 2000). Before information can be ‘avoided’ or otherwise inhibited, it first has to be detected in some way (Holmes, 1990). Thus, the positive correlation between time of first picture fixation and ARD score may indicate continuous monitoring of the experimental stimuli for *potential* threat. As outlined prior, I purposefully assessed relatively natural viewing patterns with an innocuous, low-level orientation task. That is, I used no experimental manipulation or instruction that motivated engagement/disengagement from certain types of stimuli as was done in previous (selective) attention studies in repressive coping style or in studies assessing stress effects on attention to emotional versus neutral materials (Applehans & Luecken, 2006; Ellenbogen et al., 2010; Ellenbogen et al., 2002; McHugh, Behar, Gutner, Geem, & Otto, 2010). For example, when explicitly asked to do so, repressors are better than non-repressors in suppressing negative thoughts they are asked to suppress (Barnier et al., 2004; Geraerts et al., 2007; Geraerts et al., 2006). Dichotic listening tasks (i.e., *selective* attention tasks) have shown repressors to be better at ignoring negative information than non-repressors (Bonanno, Davis, Singer, & Schwartz, 1991), when asked to do so. Schwerdtfeger and Derakshan's (2010) emotional dot-probe findings also confirmed that repressors show earlier attention and facilitated disengagement from prior threat locations on the screen if cued with an angry face, compared to non-repressors. These selective attention paradigms place very different demands on executive control of attention on repressors. An interesting related finding comes from Geraerts and others (2007) show showed that repressive individuals' ability to suppress unwanted thoughts in a thought-suppression paradigm was mediated by their increased working memory capacity. That is, repressors might be generally superior in volitional, executive control of processing resources.

To keep with the Vigilance-Avoidance Theory, it remains possible that a higher ARD, if triggered by an acute stressor, may facilitate a state of preparedness in anticipation of *potential* threat. Such could be achieved by a valence-unspecific increase in attentional vigilance. The fMRI results from Rauch and others (2007) and Paul and others (2011) used perhaps the most similar design as mine in that their passive viewing tasks also did not dictate how to attend to the stimuli. Heightened cortical **activity** in repressors during processing of emotionally charged faces, which in Paul et al. (2011) comprised not just negative emotional faces, but also happy faces. Thus, it could be speculated that anticipation of potential threat may have facilitated a state of vigilance during my attention task that was more pronounced as a function of high ARD.

Several other features of my experiment may have prevented vigilance to be selective for the negative pictures, and perhaps as a consequence, I also observed no attentional avoidance as function of high ARD, in contrast to my hypothesis. First, the nature of the picture stimuli may not have been threatening enough and the pictures were not explicitly self-relevant. As noted by Derakshan and colleagues (2007), the Vigilance Avoidance Theory pertains specifically to self-relevant threats, and not necessarily all negative information. Self-relevance in studies with repressive coping style is usually achieved by the use of verbal materials such as autobiographical information (Davis & Schwartz, 1987), verbal negative performance feedback (Mendolia & Baker, 2008), self-descriptive words (Alston et al., 2013; Fujiwara et al., 2008; Newman & McKinney, 2002) or story vignettes involving one’s own name (Hock & Krohne, 2004; Saunders et al., 2012). A clear advantage of pictures over verbal material is that pictures are more potent in inducing emotional arousal (LaBar & Cabeza, 2006). However, unlike with verbal materials, it is difficult to create truly self-relevant pictures suitable for an experiment such as mine. One possibility would have been to collect personal photos from participants’ private repertoires. However, matching such pictures in other important characteristics would have been difficult to achieve (e.g., complexity, participants’ age at the time the picture was taken, hue, luminance, etc.). An alternative that was entertained at the time of designing my study would have been to take new pictures of the participants, in the experiment. However, this approach would not have achieved the high number of clearly differentiable pictures I needed for my experiment. Thus, if avoidance of experiencing emotional arousal is a core feature of repressive coping style (Avero et al., 2003; Davis & Schwartz, 1987; Derakshan et al., 2007; Mogg et al., 2000), sufficiently arousing information, i.e., pictures as opposed to verbal materials, should be presented to evoke it. This assumption motivated my choice of pictures sacrificing self-relevance as an item feature. In retrospect, one could have used biologically relevant information, such as facial expressions. Potentially, facial expressions may have enabled avoidant viewing patterns better, as their content may have been processed faster than that of the more complex scenes. However, emotional facial expressions are also less arousal- inducing than scene pictures (Sabatinelli et al., 2011), and therefore could have also been problematic. An unexplored option for analysis of my viewing patterns is to examine the time point of first fixation on screen locations outside the picture to infer when participants first looked away from a picture. In other words, in addition to picture fixation duration and time point of first picture fixation, one could explore whether high ARD (or its components) led participants to fixate away from negative pictures earlier. Although unlikely, as overall viewing view times outside the pictures were shorter as a function of higher ARD, it remains possible that the time point of the *first* saccade away from the (negative) pictures was still earlier as a function of high ARD.

Finally, the positive correlations between ARD and viewing durations of all pictures may also have been driven by an increased task-compliance with increasing ARD: Individuals with a higher ARD, after just having been prompted with the stress-inducing performance feedback in the mental arithmetic task, could have been managing their distress by being particularly compliant and attentive to the experimental demands. Since the stress task likely represented a threat to self and social image (as discussed previously) and by definition, defensiveness is high in individuals with a repressive coping style (i.e., people on the high end of the ARD), it is possible that those individuals were particularly driven to repair their mood by trying to perform well in the next following attention task. Thus, although I designed the task with the objective of creating as little influence on natural visual patterns as possible, participants with high ARD might have shown more (or any) attentional avoidance when not acutely stressed prior to the attention task.

In summary, it appears safe to state that in a continuous visual attention paradigm with a low-level orientation task, high ARD is not associated with a vigilance-avoidance pattern for negative scene pictures, but with earlier fixations and continued attention to all pictures. This could be caused by a stress-induced/ arousal-mediated attentional focus on the task and/or better task compliance in high ARD individuals, although the lack of self-relevant picture content may have played a role as well.

4.4 Memory as a Function of Autonomic-Response Dissociation

The main memory findings were that ARD was uncorrelated to free recall accuracy and recognition sensitivity (either confident or non-confident judgements), but was associated with a less pronounced enhancement of (confident) recognition memory for negative solitary pictures compared to neutral solitary pictures. Thus, in partial agreement with hypothesis 3b, ARD was associated with *relatively* reduced emotional enhancement of memory.

There were no significant correlations between ARD and any of the four tested free recall rates (negative/neutral, solitary trials/distractor trials). As discussed above, free recall was quite low. Potential influences of individual differences on differential recall rates were therefore difficult to discern statistically. In other studies, repressive coping style has been linked to alterations in free recall in favour of retrieving self-serving information (e.g., Alston, et al., 2013; Fujiwara et al., 2008; Saunders et al., 2012). The pictures chosen here did not contain directly self-relevant features and it remains possible that these stimuli did not elicit strategic inhibition in free recall. Another possibility is that high ARD would not affect the overall accuracy in recall of negative pictures but the specific features of the pictures that were recalled. This type of content analysis was not attempted here, but appears worthwhile as a follow up. For example, when attempting to retrieve and describe a negative picture, a participant could focus on describing neutral objects in the background of the negative scene. Such a description, if containing enough detail, would have been counted as a correct recall, without coding whether recall included or excluded specifically the negative aspects of the picture.

The lack of a correlation between ARD and recognition sensitivity parallel the results in free recall accuracy. A few previous studies have assessed both recognition sensitivity and response bias in repressive coping style (Avero et al., 2003; Davis, Singer, Bonanno, & Schwartz, 1988). Davis and others (1988) found no differences in response bias in repressors compared to non-repressors in an autobiographical memory study. Using non-personal materials, Avero and others (2003) found no differences between repressors (individuals with an avoidant coping style) and non-repressors (individuals with a task-oriented or emotion-oriented coping style) in recognition sensitivity of physical threat words. However, repressors showed a more *conservative* response bias towards threat words, compared to non-repressors and no difference in response bias to neutral words, a finding in opposition to my current study which found more *liberal* response bias to negative pictures with increasing ARD (more repressive group). This discrepancy between my results and those of Avero and others (2003) may be due to the use of different materials (negative pictures versus physical threat words), or a likely more crucial difference in recognition memory procedure. Avero and colleagues' (2003) participants were provided with a stimulus set in the recognition memory task containing all old items, intermixed with lure items. That is, participants were able to look at all possible recognition choices at once, and then selected those they thought had been presented previously. In contrast, I presented recognition stimuli one at a time, so that old/new decisions had to be based on one's choice criterion in each trial, with no option to select between all possible targets and lures. Although speculative, this difference in setup could have led to favouring of 'new' responses to negative items in Avero and others, because repressors could have selectively attended to the neutral items and disregarded the negative items, which was not an option in my recognition task. Instead, high ARD in my task seems to have favoured confident recognition responses in general.

The correlation between ARD and liberal biases for making confident recognition judgements was mostly driven by correct recognition of neutral pictures, and false alarms of negative pictures. Besides floor effects in non-confident recognition judgements, a possible reason for the positive ARD correlation with confident, but not non-confident recognition may lie in the defensiveness dimension of the ARD. People with higher ratings in the self-deceptive enhancement (SDE) portion of the BIDR tend towards over-confident responses regarding their own qualities and abilities (e.g., Shane & Peterson, 2004). Participants here judged their own recognition memory quality and high ARD scorers were predominantly those with high BIDR-SDE ratings. Interestingly, *over*confidence was only seen in the recognition memory judgements for negative pictures. That is, ARD increased false confidence in one's own memory only for negative lures, an outcome that resembles findings in emotional memory regardless of coping style. People tend to overestimate their ability to learn and retrieve emotional, compared to neutral information (Talarico & Rubin, 2003; Zimmerman & Kelley, 2010). Based on my findings here, this tendency may become even more pronounced in people with high ARD.

The most interesting memory finding here was that a high ARD decreased the size of the emotional enhancement of memory (EEM): while all participants on average recognised more negative than neutral pictures, this difference was reduced as a function of ARD and particularly so for negative, compared to neutral solitary pictures. Thus, although recall/recognition rates per se were uninfluenced by ARD, the relative reductions in the EEM for negative solitary pictures followed my predictions. Based on prior findings of reduced negative memories in repressive coping (either relative to memory for neutral/non-threatening information [Alston et al., 2013; Fujiwara et al., 2008] or compared to negative memory in non-repressors; [Hock & Krohne, 2004; Krohne & Hock, 2008]), I had expected some form of reduction in negative memories as a function of high ARD.

Unlike in the attentional component of the experiment, the reduction in the EEM was largely driven by a positive correlation with self-reported negative mood in the VAS. In general, EEM is thought to be an arousal-mediated effect of amygdala-hippocampal interactions (Cahill & Alkire, 2003; Roozendaal & McGaugh, 2011). Arousal can increase encoding and post-encoding processes as has been demonstrated by injecting epinephrine or exposing participants to emotionally arousing images prior or subsequent to encoding (A. K. Anderson, Yamaguchi, Grabski, & Lacka, 2006; Cahill & Alkire, 2003; Cahill & McGaugh, 1998; Cahill, Prins, Weber, & McGaugh, 1994; Schwarze et al., 2012). The VAS and not the parameter coming closest to an arousal measure in my experiment, the SCL, mediated the relative lack of the EEM in higher ARD. In other words, people who self-reported the least mood change after the stress task were the ones with the least emotional memory enhancement. Even though the SCL was unrelated to the EEM, these people were also the ones with highest physiological response to the stress. Thus, although speculative, this could imply that people with low VAS may have performed some form of deliberate down-regulation of arousal also during the attention task. By this logic, similar to their under-rated stress levels after the stress task, stress could have been induced and regulated by non-acknowledging it if triggered by the negative solitary pictures during the encoding task and/or at the time of retrieval. Previous studies have shown that the interpretation of autonomic arousal plays a critical role in mediating effects on cognition. For example, a stress induction study by Abercrombie, Kalin, and Davidson (2005) has shown that cortisol elevations were only associated with enhanced memory consolidation in those individuals who also reported to be *emotionally* aroused (see also Todd et al., 2013). That is, the interpretation of bodily stress reactions may critically alter the effects of stress-related arousal on cognition. This also resonates with repressive coping style-specific interpretations of stress reactions: If repressors interpret arousal or stress in a less emotionally distressing way compared to non-repressors, it is possible that the normative enhancement of memory due to emotion (i.e., noradrenergic modulation of hippocampal memory via the amygdala) is diminished. Interestingly, the effect was specific to negative *solitary* picture trials. These trials likely posed the highest potential "threat" in the context of this experiment. As the subsequent memory effect correlations with ARD were also specific to this particular condition, these findings will be discussed together in more detail below.

The correlation between ARD and the size of the EEM should also be inspected from the opposite end: People with the worst reported mood after the stress task had the largest EEM. If amygdala response at the time of encoding will determine the (relative) modulation of memory by emotional materials (LaBar & Cabeza, 2006; McGaugh & Roozendaal, 2002; Talmi, 2013), and the low end of the ARD was dominated by individuals with high trait anxiety, a larger EEM becomes an obvious consequence. Neuroimaging studies in psychiatry near-uniformly report hyperactivity of the amygdala or changes in prefrontal cortex modulation of amygdala activity across many psychopathological conditions, especially mood and anxiety disorders (Drevets, 2001; Fales et al., 2008; Hariri et al., 2005; Sheline et al., 2009; Townsend & Altshuler, 2012). Patients with anxiety disorders consistently show attentional biases towards emotionally threatening materials (Ashwin et al., 2012; B. P. Bradley, Mogg, White, Groom, & Bono, 1999; Lapointe et al., 2013; LeMoult & Joormann, 2012; Shechner et al., 2012). Emotional memory biases are more variable, but if observed, they also showed increases of the EEM in patients with anxiety disorders (Coles & Heimberg, 2002; Krans, de Bree, & Bryant, 2013; Mogg, Mathews, & Weinman, 1987; Saunders, 2013). Although anxiety in my sample certainly was not in a pathological range, the correlation between high trait-anxiety and an exaggerated emotional memory enhancement appears congruent with these findings.

In summary, high ARD was associated with a relatively lowered emotional memory enhancement for negative compared to neutral scene pictures. This finding was due to less self-reported stress after the stress task. These findings could imply regulation of the physiological arousal induced specifically by negative pictures that were presented without distractors, perhaps via non-acknowledgement of subjective mood change.

4.5 Linking ARD with Attention-Memory Interactions

Does repressive coping (high ARD) act on attention/encoding, retrieval or both? This question requires inspection of several of my results together. Two important mechanisms underlying emotional memory enhancement are increased attention and increased emotional arousal at the time of encoding (e.g., Kensinger & Schacter, 2012; Talmi et al., 2007). The consistent increase in neutral and negative picture viewing time with increasing ARD speaks against a simple interpretation of repressive coping style effects lowering later memory via attention: The increase in view time did not translate into better later memory as a function of high ARD. Therefore, one may think that memory effects in repressive coping style are perhaps better understood through the operation of a mechanism at encoding unrelated to visual attention and/or through retrieval-based mechanisms.

However, ARD was selectively *positively* correlated with the size of the subsequent memory effect in free recall of negative solitary pictures (but none of the other picture types/conditions). That is, despite a lack of a correlation with free recall accuracy, the link between attention and free recall specifically of negative solitary pictures increased with higher ARD. As alluded to above, in these trials, negative content is shown on the screen for five seconds with no other items to look at. In the context of my experiment, this was probably the most anxiety-provoking trial type. Although I did not assess participants' arousal or thoughts *during* the viewing of the pictures, it is possible that individuals with high ARD scores could have engaged in verbal reinterpretation of the picture content and/or in regulation of their own emotional state *because* they had to attend to the negative pictures with nowhere else to look. The selective correlation with the self-report component of the ARD also speaks to a regulation/reinterpretation account: Those individuals with the least reported negative mood changes were the ones with the strongest free recall subsequent memory effects for negative solitary pictures. ARD was unrelated to subsequent memory effects for negative pictures presented with distractors. Although this has to remain speculative, it might not have been necessary to the same extent to engage in any defensive manoeuvers during presentation of negative pictures with distractors, and therefore, subsequent memory effects for these trials were not correlated with ARD or its subcomponents.

I previously found that negative self-relevant information was recalled less successfully by repressors than other types of materials when tested immediately after encoding while such avoidant retrieval bias was eliminated after a several day delay (Alston et al., 2013). Unlike findings pointing to a *repressive discontinuity* between preserved memory for threatening information (words, sentences, pictures) and reduced delayed recall by Hock and Krohne (2004) and Krohne and Hock (2008), I argue that repressors may engage in some form of reinterpretation of initially threatening information when given the time to do so (in the context of these prior studies, a several-day delay between encoding and retrieval). The stimuli in the current experiment were displayed on the screen for a length of five seconds and the only task was to count the items on the screen. On average, counting to '1' required participants a bit more than one second, leaving four seconds additional time unrelated to performing the counting task. What precisely people with high ARD did in those additional four seconds and whether they attempted some form of re-interpretation cannot be resolved within this experiment, although again, an in-depth analysis of the content of the written descriptions given during free recall might be a useful future step to resolve this open question.

The stronger link between attention and free recall for negative solitary pictures in people with high ARD did not actually increase recall. Thus, perhaps people with high ARD spent more visual attention to the negative solitary pictures *in order to* decrease their experienced arousal while viewing them, which would then be selectively related to memory for those particular pictures. My prior interpretation of higher task compliance in high ARD individuals agrees with this suggestion: If individuals with a higher ARD tried to do well in the encoding task, this could have been particularly difficult in trials with negative solitary pictures which may have caused stronger influences of attentional factors on later memory for those trials only. Visual attention then could have functioned to *overcome* arousal-related reactions to negative solitary picture trials, and these two effects of attention and arousal (regulation) during encoding could have canceled out. Such would render the link between attention and later memory stronger without increasing recall accuracy.

Similar to the interpretation of the ARD correlations with subsequent memory effects in free recall, it is possible that maintaining visual attention on negative pictures in which no other viewing options were present, rendered attentional influences on recognition memory stronger. The subsequent memory effect in recognition memory was correlated with SCL,in the same condition where I observed an actual decrease in the emotional enhancement of recognition memory, but this time correlated with self-reported mood. Individuals with the highest SCL changes may have used their view time in these trials as some form of arousal/emotion regulation attempt. Again, as I did not measure arousal *during* picture viewing I cannot resolve whether participants engaged in emotion regulation via attention. However, I suggest that while overtly attending to negative solitary pictures, down-regulation of emotional arousal may also have decreased the emotional impact of these pictures, decreased relative enhancements of emotional compared to neutral memory and therefore leaving visual attention more predictive of the remaining recognition accuracy (e.g., in trials in which arousal regulation was successful). Considering the selective correlations between EEM and the VAS, individuals who under-acknowledge their arousal in the stress task were also those who showed the smallest EEM. Due to the continuous nature of the ARD, this also means that those with the largest EEM were people who over-report their subjective experience of arousal. If similar mechanisms as those underlying the ARD are engaged during the encoding task, one may speculate that not acknowledging arousal may be associated with a relative neutralization of emotional pictures in memory while exaggerated interpretation of arousal may be associated with an exaggerated memory advantage of emotional over neutral pictures.

Thus, the question whether encoding or retrieval-based mechanisms mediate emotional memory in people with a repressive coping style remains only partly answered. Based on my results, I suspect that emotion regulatory efforts and/or reinterpretation of threatening implications was signified by increased attention which was only predictive of later memory in negative picture trials which left no ‘visual escape’. People can and do regulate their emotions through attentional modulation (Wadlinger & Isaacowitz, 2011) and this remains an exciting avenue for further exploration within the repressive coping style.

4.6 Limitations

A few limitations of my study should be mentioned. Overall, the effects I observed with the ARD were small, making the most obvious limitation to my study its sample size. As such, applying an estimate to my correlation results, suing an average correlation of r = 0.25 with a stringent significance level of α = 0.0125 and 80% power, the required sample size would n = 174 (Lachin, 1981). A substantial increase of my sample, as in any correlational study testing individual differences, would therefore be desirable to solidify the effects I found here and/or reject any spurious findings. In addition, there remain many additional task parameters of potential interest. For example, pupil dilation was also recorded during the attention task, which may serve as an index of arousal (Bradley, Miccoli, Escrig, & Lang, 2008) and could be particularly useful to test my speculations about the simultaneous action of visual attention and (regulation of) arousal as a function of high ARD. Another additional analysis of my viewing patterns would be to test the time point of first fixation on screen locations outside the picture.. This may clarify whether high ARD led participants to fixate away from negative pictures earlier, and may be a potential indication of attentional avoidance. In addition, a more detailed analysis of viewing patterns as they evolved during the entire five seconds could be informative. For example, one could analyse when and how often participants looked at and away from the pictures. In the free recall data, a qualitative analysis of written picture descriptions may indicate if ARD was related to recall of non-arousing details from negative pictures. Although discussed in some length above, the use of non-personal materials does pose a challenge to the specificity of my findings to the theoretical conceptualization of the repressive coping style. Null-effects can therefore always be ascribed to this shortcoming. Ideally, I would have wanted to use highly arousing, negative, and personal stimulus materials, which is problematic for practical and ethical reasons. Finally, my analytical approach was restricted to correlations and follow-up multivariate analyses (e.g., multiple regression models) would more appropriately control for false positive errors. Again, this would ideally be attempted with a larger sample size.

4.7 Future Directions

Measuring physiological arousal (via electrodermal response) during encoding and retrieval tasks would be an ideal next step to take. This would provide a direct measure of stress levels in response to my stimuli and provide a clearer picture of participants' arousal during my task, as well as an indication of how ARD may modulate these responses to the emotional pictures per se. The five second length of my stimulus presentation would be ideal for electrodermal

(SCL) measurement and may give a clearer picture of how emotionally arousing my stimuli were to each individual participant as a function of their coping style.

5. CONCLUSION

Do individuals with a repressive coping style employ vigilance and avoidance at encoding, retrieval, or a combination of the two? I found an intricate pattern of modulation of attention, memory and their link as a function of emotion and ARD which renders this initial question somewhat simplistic. Unlike prior suggestions of attentional vigilance-avoidance patterns as repressor-specific, ARD increased viewing time for emotional and non-emotional stimuli without concurrently increasing memory. While the selective advantage of emotional over neutral memory decreased as a function of ARD, the influence of attention on memory increased but only in the most emotional trial type. These findings imply that higher levels of repressive coping may lead to a stronger reliance on visual attention to serve later memory for negative information at least in situations when attentional avoidance is not possible. Thus, individuals with a repressive coping style might be able to selectively shift their attention to regulate the impact of emotional information on cognitive processes, a hypothesis that should be tested further and more directly in future studies.

REFERENCES

Abbott, R. D. (1972). On confounding of the repression-sensitization and manifest anxiety scales. *Psychological Reports, 30*, 392-394.

Abercrombie, H. C., Kalin, N. H., & Davidson, R. J. (2005). Acute cortisol elevations cause heightened arousal ratings of objectively nonarousing stimuli. *Emotion, 5*, 354-359.

Allard, E. S., & Isaacowitz, D. M. (2008). Are preferences in emotional processing affected by distraction? Examining the age-related positivity effect in visual fixation within a dual-task paradigm. *Aging, Neuropsychology, and Cognition, 15*, 725-743.

Alston, L. L., Kratchmer, C., Jeznach, A., Bartlett, N. T., Davidson, P. S. R., & Fujiwara, E. (2013). Self-serving episodic memory biases: Findings in the repressive coping style. *Frontiers in Behavioral Neuroscience, 7*, 1-10.

Altrocchi, J., Parsons, O. A., & Dickoff, H. (1960). Changes in self-ideal discrepancy in repressors and sensitizers. *The Journal of Abnormal and Social Psychology, 61*, 67-72.

Amin, Z., R., T. C., & Canli, T. (2004). Attentional bias for valenced stimuli as a function of personality in the dot-probe task. *Journal of Research in Personality, 38*, 15-23.

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General, 134*, 258-281.

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature, 411*, 305-309.

Anderson, A. K., Yamaguchi, Y., Grabski, W., & Lacka, D. (2006). Emotional memories are not all created equal: Evidence for selective memory enhancement. *Learning & Memory, 13*, 711-718.

Anderson, M. C., & Green, C. (2001). Suppressing unwanted memories by executive control. *Nature, 410*, 366-369.

Applehans, B. M., & Luecken, L. J. (2006). Attentional processes, anxiety, and the regulation of cortisol reactivity. *Anxiety, Stress, and Coping, 19*, 81-92.

Asendorpf, J. B., & Scherer, K. R. (1983). The discrepant repressor: Differentiation between low anxiety, high anxiety, and repression of anxiety by autonomic-facial-verbal patterns of behavior. *Journal of Personality and Social Psychology, 45*, 1334-1346.

Ashwin, C., Holas, P., Broadhurst, S., Kokoszka, A., Georgiou, G. A., & Fox, E. (2012). Enhanced anger superiority effect in generalized anxiety disorder and panic disorder. *Journal of Anxiety Disorders, 26*, 329-336.

Avero, P., Corace, K. M., Endler, N. S., & Calvo, M. G. (2003). Coping styles and threat processing. *Personality and Individual Differences, 35*, 843-861.

Baddeley, A. D. (1997). *Human memory: Theory and practice*. Hove, East Sussex: Psychology Press.

Bagby, R. M., Parker, J. D. A., & Taylor, G. J. (1994). The twenty-item toronto alexithymia scale—i. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research, 38*, 23-32.

Barger, S. D., Kircher, J. C., & Croyle, R. T. (1997). The effects of social context and defensiveness on the physiological responses of repressive copers. *Journal of Personality and Social Psychology, 73*, 1118-1128.

Barnier, A., Levin, K., & Maher, A. (2004). Suppressing thoughts of past events: Are repressive copers good suppressors? *Cognition & Emotion, 18,* 513-531.

Baumeister, R. F., & Cairns, K. J. (1992). Repression and self-presentation: When audiences interfere with self-deceptive strategies. *Journal of Personality and Social Psychology, 62,* 851-862.

Beckner, V. E., Tucker, D. M., Delville, Y., & Mohr, D. C. (2006). Stress facilitates consolidation of verbal memory for a film but does not affect retrieval. *Behavioral Neuroscience, 120*, 518.

Bendig, A. W. (1956). The development of a short form of the manifest anxiety scale. *Journal of Consulting Psychology, 20*, 384.

Berggren, N., Koster, E. H. W., & Derakshan, N. (2012). The effect of cognitive load in emotional attention and trait anxiety: An eye-movement study. *Journal of Cognitive Psychology, 24*, 79-91.

Bijttebier, P., Vertommen, H., & Steene, G. V. (2001). Assessment of cognitive coping styles: A closer look at situation-response inventories. *Clinical Psychology Review, 21*, 85-104.

Biopac Systems, I. (2000). MP system hardware guide, 2000, from http://www.biopac.com/Manuals/mp_hardware_guide.pdf

Blackhart, G. C., & Kline, J. P. (2005). Individual differences in anterior eeg asymmetry between high and low defensive individuals during a rumination/distraction task. *Personality and Individual Differences, 39,* 427-437.

Bonanno, G. A., Davis, P. J., Singer, J. L., & Schwartz, G. E. (1991). The repressor personality and avoidant information processing: A dichotic listening study. *Journal of Research in Personality, 25*, 386-401.

Boucsein, W. (2012). *Electrodermal activity*: Springer. New York, NY: Springer.

Bradley, B. P., Mogg, K., Falla, S. J., & Hamilton, L. R. (1998). Attentional bias for threatening facial expressions in anxiety: Manipulation of stimulus duration. *Cognition & Emotion, 12*, 737-753.

Bradley, B. P., Mogg, K., White, J., Groom, C., & Bono, J. (1999). Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology, 38*, 267-278.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*, 49-59.

Bradley, M. M., Miccoli, L., Escrig, M. A., & Lang, P. J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology, 45*, 602-607.

Brophy, A. L. (1986). Alternatives to a table of criterion values in signal detection theory. *Behavior Research Methods, Instruments, & Computers, 18,* 285-286.

Brosschot, J. F., De Ruiter, C., & Kindt, M. (1999). Recall and recognition of threatening, pleasant, and neutral words in repressors. *European Journal of Personality, 13*, 1-14.

Brosschot, J. F., & Janssen, E. (1998). Continuous monitoring of affective-autonomic response dissociation in repressers during negative emotional stimulation. *Personality and Individual Differences, 25*, 69-84.

Brune, M., Nadolny, N., Gunturkun, O., & Wolf, O. T. (2013). Stress induces a functional asymmetry in an emotional attention task. *Cognition and Emotion, 27*, 558-566.

Bulevich, J. B., Roediger, H. L., 3rd, Balota, D. A., & Butler, A. C. (2006). Failures to find suppression of episodic memories in the think/no-think paradigm. *Memory & Cognition, 34*, 1569-1577.

Burns, J. W., Quartana, P. J., Elfant, E., Matsuura, J., Gilliam, W., Nappi, C., et al. (2010). Shifts in attention biases in response to acute pain induction: Examination of a model of "conversion" among repressors. *Emotion, 10,* 755-766.

Byrne, D., Barry, J., & Nelson, D. (1963). The revised repression sensitization scale and its relationship to measures of self-description. *Psychological Reports, 13*, 323-334.

Cahill, L., & Alkire, M. T. (2003). Epinephrine enhancement of human memory consolidation: Interaction with arousal at encoding. *Neurobiology of Learning and Memory, 79*, 194-198.

Cahill, L., & McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences, 21*, 294-299.

Cahill, L., Prins, B., Weber, M., & McGaugh, J. L. (1994). B-adrenergic activation and memory for emotional events. *Nature, 371*, 702-704.

Caldwell, T. L., & Newman, L. S. (2005). The timeline of threat processing in repressors: More evidence for early vigilance and late avoidance. *Personality and Individual Differences, 38*, 1957-1967.

Calvo, M. G., & Eysenck, M. W. (2000). Early vigilance and late avoidance of threat processing: Repressive coping versus high/low anxiety. *Cognition & Emotion, 14*, 763-787.

Calvo, M. G., & Lang, P. J. (2004). Gaze patterns when looking at emotional pictures: Motivationally biased attention. *Motivation and Emotion, 28,* 221-243.

Calvo, M. G., & Lang, P. J. (2005). Parafoveal semantic processing of emotional visual scenes. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 502-519.

Carver, C. S., & Scheier, M. F. (1981). The self-attention-induced feedback loop and social facilitation. *Journal of Experimental Social Psychology, 17,* 545-568.

Cavanagh, J. F., Frank, M. J., & Allen, J. J. B. (2011). Social stress reactivity alters reward and punishment learning. *Social Cognitive and Affective Neuroscience, 6*, 311-320.

Chajut, E., & Algom, D. (2003). Selective attention improves under stress: Implications for theories of social cognition. *Journal of Personality and Social Psychology, 85*, 231-248.

Chan, M., & Singhal, A. (2013). The emotional side of cognitive distraction: Implications for road safety. *Accident Analysis & Prevention, 50*, 147-154.

Christianson, S. A., Loftus, E. F., Hoffman, H., & Loftus, G. R. (1991). Eye fixations and memory for emotional events. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 17*, 693-701.

Coifman, K. G., Bonanno, G. A., Ray, R. D., & Gross, J. J. (2007). Does repressive coping promote resilience? Affective-autonomic response discrepancy during bereavement. *Journal of Personality and Social Psychology, 92*, 745-758.

Coles, M. E., & Heimberg, R. G. (2002). Memory biases in the anxiety disorders: Current status. *Clinical Psychology Review, 22*, 587-627.

Crawford, H. J., Clarke, S. W., & Kitner-Triolo, M. (1996). Self-generated happy and sad emotions in low and highly hypnotizable persons during waking and hypnosis: Laterality and regional EEG activity differences. *International Journal of Psychophysiology, 24*, 239-266.

Crowne, D. P., & Marlowe, D. (1964). *The approval motive*. New York: John Wiley & Sons.

Davis, P. J. (1990). Repression and the inaccessibility of emotional memory. In J. L. Singer (Ed.), *Repression and dissociation* (pp. 387-434). Chicago: Chicago University Press.

Davis, P. J., & Schwartz, G. E. (1987). Repression and the inaccessibility of affective memories. *Journal of Personality and Social Psychology, 52*, 155-162.

Davis, P. J., Singer, J. L., Bonanno, G. A., & Schwartz, G. E. (1988). Repression and response bias during an affective memory recognition task. *Australian Journal of Psychology, 40*, 147-157.

de Quervain, D. J. (2006). Glucocorticoid-induced inhibition of memory retrieval: Implications for posttraumatic stress disorder. *Annals of the New York Academy of Sciences, 1071*, 216-220.

Depue, B. E., Banich, M. T., & Curran, T. (2006). Suppression of emotional and nonemotional content in memory: Effects of repetition on cognitive control. *Psychological Science, 17*, 441-447.

Derakshan, N. (1999). Are repressors self-deceivers or other-deceivers? *Cognition & Emotion, 13*, 1-17.

Derakshan, N., & Eysenck, M. W. (1997). Interpretive biases for one's own behavior and physiology in high-trait-anxious individuals and repressors. *Journal of Personality and Social Psychology, 73*, 816-825.

Derakshan, N., Eysenck, M. W., & Myers, L. B. (2007). Emotional information processing in repressors: The vigilance-avoidance theory. *Cognition And Emotion, 21*, 1585-1614.

Derakshan, N., Feldman, M., Campbell, T., & Lipp, O. (2003). *Can I have your attention please: Repressors and enhanced p3 to emotional stimuli.* Paper presented at Psychophysiology, annual meeting.

Dolan, R. J., & Vuilleumier, P. (2003). Amygdala automaticity in emotional processing. *Annals of the New York Academy of Sciences, 985*, 348-355.

Dolcos, F., & Cabeza, R. (2002). Event-related potentials of emotional memory: Encoding pleasant, unpleasant, and neutral pictures. *Cognitive, Affective & Behavioral Neuroscience, 2*, 252-263.

Dolcos, F., LaBar, K. S., & Cabeza, R. (2004). Interaction between the amygdala and the medial temporal lobe memory system predicts better memory for emotional events. *Neuron, 42*, 855-863.

Dolcos, F., & McCarthy, G. (2006). Brain systems mediating cognitive interference by emotional distraction. *The Journal of Neuroscience, 26*, 2072-2079.

Dominique, J.-F., Roozendaal, B., Nitsch, R. M., McGaugh, J. L., & Hock, C. (2000). Acute cortisone administration impairs retrieval of long-term declarative memory in humans. *Nature Neuroscience, 3*, 313-314.

Dougal, S., Rotello, C. (2007). "Remembering" emotional words is based on response bias, not recollection. *Psychonomic Bulletin & Review, 14*, 423-429.

Drevets, W. C. (2001). Neuroimaging and neuropathological studies of depression: Implications for the cognitive-emotional features of mood disorders. *Current Opinion in Neurobiology, 11*, 240-249.

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66*, 183-201.

Egloff, B., & Hock, M. (2003). Assessing attention allocation toward threat-related stimuli: A comparison of the emotional stroop task and the attentional probe task. *Personality and Individual Differences, 35*, 475-483.

Egloff, B., & Krohne, H. W. (1996). Repressive emotional discreteness after failure. *Journal of Personality and Social Psychology, 70*, 1318-1326.

Egner, T., Etkin, A., Gale, S., & Hirsch, J. (2008). Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. *Cerebral Cortex, 18*, 1475-1484.

Ellenbogen, M. A., Carson, R. J., & Pishva, R. (2010). Automatic emotional information processing and the cortisol response to acute psychosocial stress. *Cognitive, Affective, & Behavioral Neuroscience, 10*, 71-82.

Ellenbogen, M. A., Schwartzman, A. E., Stewart, J., & Walker, C. D. (2002). Stress and selective attention: The interplay of mood, cortisol levels, and emotional information processing. *Psychophysiology, 39*, 723-732.

Erdelyi, M. H. (2006). The unified theory of repression. *Behavioural and Brain Sciences, 29*, 499-511.

Erk, S., Kiefer, M., Grothe, J., Wunderlich, A. P., Spitzer, M., & Walter, H. (2003). Emotional context modulates subsequent memory effect. *Neuroimage, 18*, 439-447.

Eysenck, H. J., & Eysenck, S. B. G. (1964). Manual of the Eysenck personality inventory. London: University of London Press.

Eysenck, M. W. (1997). *Anxiety and cognition: A unified theory*.Hove, East Sussex: Psychology Press.

Fales, C. L., Barch, D. M., Rundle, M. M., Mintun, M. A., Snyder, A. Z., Cohen, J. D., et al. (2008). Altered emotional interference processing in affective and cognitive-control brain circuitry in major depression. *Biological Psychiatry, 63*, 377-384.

Farroni, T., Csibra, G., Simion, F., & Johnson, M. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences, 99*, 9602-9605.

Fenske, M. J., & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. *Emotion, 3*, 327-343.

Flavell, J. H. (1955). Repression and the "return of the repressed". *Journal of Consulting Psychology, 19*, 441-443.

Fowles, D. C. (1980). The three arousal model: Implications of gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology, 17*, 87-104.

Fowles, D. C., Fisher, A. E., & Tranel, D. T. (1982). The heart beats to reward: The effect of monetary incentive on heart rate. *Psychophysiology, 19*, 506-513.

Freud, S. (1957/1915). Repression. In J. Strachey (Ed.), *The standard edition of the complete psychological works of Sigmund Freud* (Vol. 14). London: Hogarth Press (originally published in 1915).

Frischen, A., Eastwood, J. D., & Smilek, D. (2008). Visual search for faces with emotional expressions. *Psychological Bulletin, 134*, 662-676.

Fujiwara, E., Levine, B., & Anderson, A. K. (2008). Intact implicit and reduced explicit memory for negative self-related information in repressive coping. *Cognitive, Affective, & Behavioral Neuroscience, 8*, 254-263.

Fuller, B. F. (1992). The effects of stress-anxiety and coping styles on heart rate variability. *International Journal of Psychophysiology, 12*, 81-86.

Geraerts, E., Merckelbach, H., Jelicic, M., & Habets, P. (2007). Suppression of intrusive thoughts and working memory capacity in repressive coping. *American Journal of Psychology, 120*, 205-218.

Geraerts, E., Merckelbach, H., Jelicic, M., & Smeets, E. (2006). Long term consequences of suppression of intrusive anxious thoughts and repressive coping. *Behavior Research and Therapy, 44*, 1451-1460.

Gudjonsson, G. H. (1981). Self-reported emotional disturbance and its relation to electrodermal reactivity, defensiveness and trait anxiety. *Personality and Individual Differences, 2*, 47-52.

Guo, K., Tunnicliffe, D., & Roebuck, H. (2010). Human spontaneous gaze patterns in viewing of faces of different species. *Perception, 39*, 533-542.

Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences, 5*, 394-400.

Hansen, C. H., Hansen, R. D., & Shantz, D. W. (1992). Repression at encoding: Discrete appraisals of emotional stimuli. *Journal of Personality and Social Psychology, 63*, 1026-1035.

Hansen, R. D., & Hansen, C. H. (1988). Repression of emotionally tagged memories: The architecture of less complex emotions. *Journal of Personality and Social Psychology, 55*, 811-818.

Hariri, A. R., Drabant, E. M., Munoz, K. E., Kolachana, B. S., Mattay, V. S., Egan, M. F., et al. (2005). A susceptibility gene for affective disorders and the response of the human amygdala. *Archives of General Psychiatry, 62,* 146.

Harrison, J. A., & Watson, D. (1992). The dissociative processes scale. Department of Psychology, University of Iowa, unpublished.

Hertel, P., & McDaniel, L. (2010). The suppressive power of positive thinking: Aiding suppression-induced forgetting in repressive coping. *Cognition & Emotion, 24*, 1239-1249.

Highland, A. C. (1980). Confounding of the repression-sensitization scale, controlled for social desirability, with the ip at anxiety scale. *Psychological Reports, 47*, 1003-1006.

Hock, M., & Egloff, B. (1998). Interindividuelle Differenzen in Priming-und Gedächtniseffekten bedrohungsbezogener Stimuli: Der Einfluß kognitiv vermeidender und vigilanter Angstbewältigung. *Zeitschrift für experimentelle Psychologie, 45*, 149-166.

Hock, M., & Krohne, H. W. (2004). Coping with threat and memory for ambiguous information: Testing the repressive discontinuity hypothesis. *Emotion, 4*, 65-86.

Holmes, D. S. (1990). The evidence of repression: An examnation of sixty years of research. In J. L. Singer (Ed.), *Repression and dissociation: Defense mechanisms and personality styles*. Chicago: University Press.

Ioannou, M. C., Mogg, K., & Bradley, B. P. (2004). Vigilance for threat: Effects of anxiety and defensiveness. *Personality and Individual Differences, 36,* 1879-1891.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006). Is there an age-related positivity effect in visual attention? A comparison of two methodologies. *Emotion, 6*, 511-516.

Jelici, M., Geraerts, E., Merckelbach, H., & Guerrieri, R. (2004). Acute stress enhances memory for emotional words, but impairs memory for neutral words. *International Journal of Neuroscience, 114*, 1343-1351.

Jonides, J. (1981). Voluntary versus automatic control over the mind's eye's movement. In J. Long & A. Baddeley (Eds.), *Attention and performance* (pp. 187-203). Hillsdale, NJ: Erlbaum.

Jorgensen, M., & Zachariae, R. (2006). Repressive coping style and autonomic reactions to two experimental stressors in healthy men and women. *Scandinavian Journal of Psychology, 47,* 137-148.

Kensinger, E. A., Brierley, B., Medford, N., Growdon, J. H., & Corkin, S. (2002). Effects of normal aging and alzheimer's disease on emotional memory. *Emotion, 2*, 118-134.

Kensinger, E. A., & Corkin, S. (2004). Two routes to emotional memory: Distinct neural processes for valence and arousal. *Proceedings of the National Academy of Sciences of the United States of America, 101*, 3310-3315.

Kensinger, E. A., Garoff-Eaton, R. J., & Schacter, D. L. (2007). Effects of emotion on memory specificity in young and older adults. *Journal of Gerontology, 62*, 2018-2215.

Kensinger, E. A., & Schacter, D. L. (2006). Amygdala activity is associated with the successful encoding of item, but not source, information for positive and negative stimuli. *The Journal of Neuroscience, 26*, 2564-2570.

Kensinger, E. A., & Schacter, D. L. (2012). Memory and emotion. In M. Lewis (Ed.), *Handbook of emotions* (3 ed., pp. 601-617). New York, NY: The Guilford Press.

Kern, R. P., Libkuman, T. M., Otani, H., & Holmes, K. (2005). Emotional stimuli, divided attention, and memory. *Emotion, 5*, 408-417.

Kim, J. S.-C., Vossel, G., & Gamer, M. (2013). Effects of emotional context on memory for details: The role of attention. *PLOS ONE, 8*, e77405.

Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The ‘trier social stress test’–a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28*, 76-81.

Kline, J. P., Allen, J. J. B., & Schwartz, G. E. (1998). Is left frontal brain activation in defensiveness gender specific? *Journal of Abnormal Psychology, 107*, 149-153.

Kline, J. P., Knapp-Kline, K., Schwartz, G. E. R., & Russek, L. G. S. (2001). Anterior asymmetry, defensiveness, and perceptions of parental caring. *Personality and Individual Ddifferences, 31*, 1135-1145.

Koster, E. H. W., Crombez, G., Verschuere, B., & De Houwer, J. (2004). Selective attention to threat in the dot probe paradigm: Differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy, 42*, 1183-1192.

Krans, J., de Bree, J., & Bryant, R. A. (2013). Autobiographical memory bias in social anxiety. *Memory*, 1-8.

Krohne, H. W. (1986). *Coping with stress*.New York, NY: Springer.

Krohne, H. W. (1993). *Attention and avoidance: Strategies in coping with aversiveness*. Ashland, OH: Hogrefe & Huber Publishers.

Krohne, H. W., Egloff, B., Varner, L. J., Burns, L. R., Weidner, G., & Ellis, H. C. (2000). The assessment of dispositional vigilance and cognitive avoidance: Factorial structure, psychometric properties, and validity of the mainz coping inventory. *Cognitive Therapy and Research, 24*, 297-311.

Krohne, H. W., & Hock, M. (2008). Cognitive avoidance, positive affect, and gender as predictors of the processing of aversive information. *Journal of Research in Personality, 42*, 1572-1584.

Kuhlmann, S., Piel, M., & Wolf, O. T. (2005). Impaired memory retrieval after psychosocial stress in healthy young men. *The Journal of Neuroscience, 25*, 2977-2982.

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience, 7*, 54-64.

Lachin, J. M. (1981). Introduction to sample size determination and power analysis for clinical trials. *Controlled Clinical Trials, 2,* 93-113.

Lamy, D., Amunts, L., & Bar-Haim, Y. (2008). Emotional priming of pop-out in visual search. *Emotion, 8*, 151-161.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). International affective picture system (iaps): Technical manual and affective ratings. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual. Technical report a-8*. Gainesville, FL: University of Florida.

Lapointe, M.-L. B., Blanchette, I., Duclos, M., Langlois, F., Provencher, M. D., & Tremblay, S. (2013). Attentional bias, distractibility and short-term memory in anxiety. *Anxiety, Stress & Coping, 26*, 293-313.

Leary, M. R., Terry, M. L., Allen, A. B., & Tate, E. B. (2009). The concept of ego threat in social and personality psychology: Is ego threat a viable scientific construct? *Personality and Social Psychology Review, 13*, 151-164.

LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience, 23*, 155-184.

LeMoult, J., & Joormann, J. (2012). Attention and memory biases in social anxiety disorder: The role of comorbid depression. *Cognitive Therapy and Research, 36*, 47-57.

Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about" weapon focus". *Law and Human Behavior, 11*, 55-62.

MacLeod, C., & Mathews, A. (1988). Anxiety and the allocation of attention to threat. *The Quarterly Journal of Experimental Psychology, 40*, 653-670.

Macmillan, N. A. (1993). Signal detection theory as data analysis method and psychological decision model. *A Handbook For Data Analysis in The Behavioral Sciences: Methodological Issues*, 21-57. Broadway, NJ: Lawrence Erlbaum Associates, Inc.

Madan, C. R., Fujiwara, E., Gerson, B. C., & Caplan, J. B. (2012). High reward makes items easier to remember, but harder to bind to a new temporal context. *Frontiers in Integrative Neuroscience, 6,* 61.

Masciocchi, C. M., Mihalas, S., Parkhurst, D., & Niebur, E. (2009). Everyone knows what is interesting: Salient locations which should be fixated. *Journal of Vision, 9*, 1-22.

Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences, 9*, 496-502.

McGaugh, J. L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience, 27,* 1-28.

McGaugh, J. L., & Roozendaal, B. (2002). Role of adrenal stress hormones in forming lasting memories in the brain. *Current Opinion in Neurobiology, 12*, 205-210.

McHugh, R. K., Behar, E., Gutner, C. A., Geem, D., & Otto, M. W. (2010). Cortisol, stress, and attentional bias toward threat. *Anxiety, Stress, & Coping, 23*, 529-545.

McKenna, F. P., & Sharma, D. (1995). Intrusive cognitions: An investigation of the emotional stroop task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 1595-1607.

McNally, R. J., Clancy, S. A., & Barrett, H. M. (2004). *Forgetting trauma?* New York, NY: Oxford University Press.

Mendolia, M. (2002). An index of self-regulation of emotion and the study of repression in social contexts that threaten or do not threaten self-concept. *Emotion, 2*, 215-232.

Mendolia, M., & Baker, G. A. (2008). Attentional mechanisms associated with repressive distancing. *Journal of Research in Personality, 42*, 546-563.

Mogg, K., Bradley, B. P., De Bono, J., & Painter, M. (1997). Time course of attentional bias for threat information in non-clinical anxiety. *Behaviour Research and Therapy, 35*, 297-303.

Mogg, K., Bradley, B. P., Dixon, C., Fisher, S., Twelftree, H., & McWilliams, A. (2000). Trait anxiety, defensiveness and selective processing of threat: An investigation using two measures of attentional bias. *Personality and Individual Differences, 28*, 1063-1077.

Mogg, K., Mathews, A., & Weinman, J. (1987). Memory bias in clinical anxiety. *Journal of Abnormal Psychology, 96*, 94-98.

Morris, J. S., DeGelder, B., Weiskrantz, L., & Dolan, R. J. (2001). Differential extrageniculostriate and amygdala responses to presentation of emotional faces in a cortically blind field. *Brain, 124*, 1241-1252.

Morris, J. S., Ohman, A., & Dolan, R. J. (1998). Conscious and unconscious emotional learning in the human amygdala. *Nature, 393*, 467-470.

Mund, M., & Mitte, K. (2012). The costs of repression: A meta-analysis on the relation between repressive coping and somatic diseases. *Health Psychology, 31*, 640-649.

Myers, L. B. (2010). The importance of the repressive coping style: Findings from 30 years of research. *Anxiety, Stress & Coping, 23*, 3-17.

Myers, L. B., & Brewin, C. R. (1994). Recall of early experience and the repressive coping style. *Journal of Abnormal Psychology, 103*, 288-292.

Myers, L. B., & Brewin, C. R. (1996). Illusions of well-being and the repressive coping style. *British Journal of Social Psychology, 35*, 443-457.

Myers, L. B., Brewin, C. R., & Power, M. J. (1998). Repressive coping and the directed forgetting of emotional material. *Journal of Abnormal Psychology, 107*, 141-148.

Myers, L. B., & Derakshan, N. (2004). To forget or not to forget: What do repressors forget and when do they forget? *Cognition and Emotion, 18*, 495-511.

Newman, L. S., & McKinney, L. C. (2002). Repressive coping and threat-avoidance: An idiographic stroop study. *Personality and Social Psychology Bulletin, 28*, 409-422.

Newton, T. L., & Contrada, R. J. (1992). Repressive coping and verbal-autonomic response dissociation: The influence of social context. *Journal of Personality and Social Psychology, 62*, 159-167.

Nummenmaa, L., Hyönä, J., & Calvo, M. G. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion, 6*, 257-268.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*, 466-478.

Oldenburg, C., Lundh, L.-G., & Kivisto, P. (2002). Explicit and implicit memory, trait anxiety, and repressive coping style. *Personality and Individual Differences, 32*, 107-119.

Paul, V. G., Rauch, A. V., Kugel, H., Horst, L. T., Bauer, J., Dannlowski, U., et al. (2011). High responsivity to threat during the initial stage of perception in repression: A 3T fmri study. *Social Cognitive and Affective Neuroscience*, 1-11.

Paulhus, D. L. (1991). Measurement and control of response bias. In J. P. Robinson, P. R. Shaver & L. S. Wrightsman (Eds.), *Measures of personality and social psychological attitudes* (pp. 17-59). San Diego: Academic Press.

Pauls, C. A., & Stemmler, G. (2003). Repressive and defensive coping during fear and anger. *Emotion, 3*, 284-302.

Pauls, C. A., Wacker, J., & Crost, N. W. (2005). The two components of social desirability and their relations to resting frontal brain asymmetry. *Journal of Individual Differences, 26*, 29-42.

Pessoa, L. (2005). To what extent are emotional visual stimuli processed without attention and awareness? *Current Opinion in Neurobiology,15*, 188-196.

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Neuroscience Reviews 9*, 148-158.

Peters, J. H., Hock, M., & Krohne, H. W. (2012). Sensitive maintenance: A cognitive process underlying individual differences in memory for threatening information (Vol. 102, pp. 200-213). US: American Psychological Association.

Pilgrim, K., Marin, M. F., & Lupien, S. J. (2010). Attentional orienting toward social stress stimuli predicts increased cortisol responsivity to psychosocial stress irrespective of the early socioeconomic status. *Psychoneuroendocrinology, 35*, 588-595.

Piper Jr, A., Pope Jr, H. G., & Borowiecki III, J. J. (2000). Custer's last stand: Brown, scheflin'and whitfield's latest attempt to salvage dissociative amnesia. *Journal of Psychiatry & Law, 28*, 149-213.

Plessow, F., Kiesel, A., & Kirschbaum, C. (2012). The stressed prefrontal cortex and goal-directed behaviour: Acute psychosocial stress impairs the flexible implementation of task goals. *Experimental Brain Research, 216*, 397-408.

Plessow, F., Schade, S., Kirschbaum, C., & Fischer, R. (2012). Better not to deal with two tasks at the same time when stressed? Acute psychosocial stress reduces task shielding in dual-task performance. *Cognitive, Affective & Behavioral Neuroscience, 12*, 557-570.

Quigley, L., Nelson, A. L., Carriere, J., Smilek, D., & Purdon, C. (2012). The effects of trait and state anxiety on attention to emotional images: An eye-tracking study. *Cognition & Emotion, 26*, 1390-1411.

Rauch, A. V., Ohrmann, P., Bauer, J., Kugel, H., Engelien, A., Arolt, V., et al. (2007). Cognitive coping style modulates neural responses to emotional faces in healthy humans: A 3-t fmri study. *Cerebral Cortex, 17*, 2526-2535.

Reisberg, D. E., & Heuer, F. (2004). Remembering emotional events. In D. E. Reisberg & P. T. Hertel (Eds.), *Memory & emotion* (pp. 3-41). New York: Oxford University Press.

Richardson, M. P., Strange, B. A., & Dolan, R. J. (2004). Encoding of emotional memories depends on amygdala and hippocampus and their interactions. *Nature Neuroscience, 7*, 278-285.

Riggs, L., McQuiggan, D. A., Anderson, A. K., & Ryan, J. D. (2010). Eye movement monitoring reveals differential influences of emotion on memory. *Frontiers in Psychology, 1*, 1-9.

Riggs, L., McQuiggan, D. A., Farb, N., Anderson, A. K., & Ryan, J. D. (2011). The role of overt attention in emotion-modulated memory. *Emotion, 11*, 776-785.

Roediger, H. L. W., M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger (Ed.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving.* (pp. 3-41). New Jersey: Lawrence Erlbaum Associates, Inc.

Roelofs, K., Bakvis, P., Hermans, E. J., van Pelt, J., & van Honk, J. (2007). The effects of social stress and cortisol responses on the preconscious selective attention to social threat. *Biological Psychology, 75*, 1-7.

Roozendaal, B., & McGaugh, J. L. (2011). Memory modulation. *Behavioral neuroscience, 125*, 797-824.

Rosenzweig, S., & Mason, G. (1934). An experimental study of memory in relation to the theory of repression. *British Journal of Psychology, 24*, 247-265.

Sabatinelli, D., Fortune, E. E., Li, Q., Siddiqui, A., Krafft, C., Oliver, W. T., et al. (2011). Emotional perception: Meta-analyses of face and natural scene processing. *Neuroimage, 54*, 2524-2533.

Sandi, C., & Pinelo-Nava, M. T. (2007). Stress and memory: Behavioral effects and neurobiological mechanisms. *Neural Plasticity, 2007*, 1-20.

Saunders, J. (2013). Selective memory bias for self-threatening memories in trait anxiety. *Cognition & Emotion, 27*, 21-36.

Saunders, J., Worth, R., & Fernandes, M. (2012). Repressive coping style and mnemic neglect. *Journal of Experimental Psychopathology, 3*, 346-367.

Schimmack, U., & Hartmann, K. (1997). Individual differences in the memory representation of emotional episodes: Exploring the cognitive processes in repression. *Journal of Personality and Social Psychology, 73*, 1064-1079.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-prime user's guide*. Pittsburgh, PA: Psychology Software Tools, Inc.

Schwarze, U., Bingel, U., & Sommer, T. (2012). Event-related nociceptive arousal enhances memory consolidation for neutral scenes. *The Journal of Neuroscience, 32*, 1481-1487.

Schwerdtfeger, A., & Derakshan, N. (2010). The time line of threat processing and vagal withdrawal in response to a self-threatening stressor in cognitive avoidant copers: Evidence for vigilance-avoidance theory. *Psychophysiology, 47*, 786-795.

Shane, M., & Peterson, J. B. (2004). Self-induced memory distortions and the allocation of processing resources at encoding and retrieval. *Cognition & Emotion, 18*, 533-558.

Sharot, T., & Phelps, E. A. (2004). How arousal modulates memory: Disentangling the effects of attention and retention. *Cognitive, Affective & Behavioral Neuroscience, 4*, 294-306.

Shechner, T., Britton, J. C., Pérez-Edgar, K., Bar-Haim, Y., Ernst, M., Fox, N. A., et al. (2012). Attention biases, anxiety, and development: Toward or away from threats or rewards? *Depression and Anxiety, 29*, 282-294.

Sheline, Y. I., Barch, D. M., Price, J. L., Rundle, M. M., Vaishnavi, S. N., Snyder, A. Z., et al. (2009). The default mode network and self-referential processes in depression. *Proceedings of the National Academy of Sciences, 106*, 1942-1947.

Simoens, V. L., Istok, E., Hyttinen, S., Hirvonen, A., Naatanen, R., & Tervaniemi, M. (2007). Psychosocial stress attenuates general sound processing and duration change detection. *Psychophysiology, 44*, 30-38.

Slough, N., Kleinknecht, R. A., & Thorndike, R. M. (1984). Relationship of the repression-sensitization scales to anxiety. *Journal of Personality Assessment, 48*, 378-379.

Smeets, T., Giesbrecht, T., Jelicic, M., & Merckelbach, H. (2007). Context-dependent enhancement of declarative memory performance following acute psychosocial stress. *Biological Psychology, 76*, 116-123.

Spielberger, C. D., Gorsuch, R. L., Lushene, R. E., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stagner, R. (1931). The reintegration of pleasant and unpleasant experiences. *American Journal of Psychology, 43*, 463-468.

Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers, 31*, 137-149.

Strange, B. A., & Dolan, R. J. (2004). Beta-adrenergic modulation of emotional memory-evoked human amygdala and hippocampal responses. *Proceedings of the National Academy of Sciences of the United States of America, 101*, 11454-11458.

Talarico, J. M., & Rubin, D. C. (2003). Confidence, not consistency, characterizes flashbulb memories. *Psychological Science, 14*, 455-461.

Talmi, D. (2013). Enhanced emotional memory cognitive and neural mechanisms. *Current Directions in Psychological Science, 22*, 430-436.

Talmi, D., & McGarry, L. M. (2012). Accounting for immediate emotional memory enhancement. *Journal of Memory and Language, 66*, 93-108.

Talmi, D., & Moscovitch, M. (2004). Can semantic relatedness explain the enhancement of memory for emotional words? *Memory & Cognition, 32*, 742-751.

Talmi, D., Riggs, L., Caplan, J. B., & Moscovitch, M. (2008). Immediate memory consequences of the effect of emotion on attention to pictures. *Learning & Memory, 15*, 172-182.

Talmi, D., Schimmack, U., Paterson, T., & Moscovitch, M. (2007). The role of attention and relatedness in emotionally enhanced memory. *Emotion, 7*, 89-102.

Taylor, J. A. (1953). A personality scale of manifest anxiety. *The Journal of Abnormal and Social Psychology, 48*, 285-290.

Terburg, D., Aarts, H., & van Honk, J. (2012). Memory and attention for social threat: Anxious hypercoding-avoidance and submissive gaze aversion. *Emotion, 12*, 666-672.

Theeuwes, J. (1991). Exogenous and endogenous control of attention: The effect of visual onsets and offsets. *Perception & Psychophysics, 49*, 83-90.

Todd, R. M., Müller, D. J., Palombo, D. J., Robertson, A., Eaton, T., Freeman, N., et al. (2013). Deletion variant in the adra2b gene increases coupling between emotional responses at encoding and later retrieval of emotional memories. *Neurobiology of Learning and Memory*, DOI:10.1016/j.nlm.2013.10.008.

Tomaka, J., Blascovich, J., & Kelsey, R. M. (1992). Effects of self-deception, social desirability, and repressive coping on psychophysiological reactivity to stress. *Personality and Social Psychology Bulletin, 18*, 616-624.

Tomarken, A. J., & Davidson, R. J. (1994). Frontal brain activation in repressors and nonrepressors. *Journal of Abnormal Psychology, 103*, 339-349.

Townsend, J., & Altshuler, L. L. (2012). Emotion processing and regulation in bipolar disorder: A review. *Bipolar Disorders, 14*, 326-339.

Tranel, D. T. (1983). The effects of monetary incentive and frustrative nonreward on heart rate and electrodermal activity. *Psychophysiology, 20*, 652-657.

Trull, T. J., & Durrett, C. A. (2005). Categorical and dimensional models of personality disorder. *Annual Review of Clinical Psychology, 1*, 355-380.

Tukey, J. W. (1977). Exploratory data analysis (pp. 5-23). Massachusetts: Addison-Wesley

van Honk, J., Tuiten, A., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., et al. (2000). Conscious and preconscious selective attention to social threat: Different neuroendocrine response patterns. *Psychoneuroendocrinology, 25*, 577-591.

Vendemia, J., & Rodriguez, P. D. (2010). Repressors vs. Low-and high-anxious coping styles: EEG differences during a modified version of the emotional stroop task. *International Journal of Psychophysiology, 78*, 284-294.

Vuilleumier, P., & Schwartz, S. (2001). Emotional facial expressions capture attention. *Neurology, 56*, 153-158.

Wadlinger, H. A., & Isaacowitz, D. M. (2006). Positive mood broadens visual attention to positive stimuli. *Motivation & Emotion, 30*, 87-99.

Wadlinger, H. A., & Isaacowitz, D. M. (2011). Fixing our focus: Training attention to regulate emotion. *Personality and Social Psychology Review, 15*, 75-102.

Wagner, A. D., Koutstaal, W., & Schacter, D. L. (1999). When encoding yields remembering: Insights from event-related neuroimaging. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 354*, 1307-1324.

Wagner, A. D., Schacter, D. L., Rotte, M., Koutstaal, W., Maril, A., Dale, A. M., et al. (1998). Building memories: Remembering and forgetting of verbal experiences as predicted by brain activity. *Science, 281*, 1188-1191.

Watson, D. (2003). Investigating the construct validity of the dissociative taxon: Stability analyses of normal and pathological dissociation. *Journal of Abnormal Psychology, 112*, 298-305.

Wegner, D. M., Schneider, D. J., Carter, S. R., & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53*, 5-13.

Weinberger, D. A. (1990). The construct validity of the repressive coping style. In J. L. Singer (Ed.), *Repression and dissociation* (pp. 337-386). Chicago: Chicago University Press.

Weinberger, D. A., & Davidson, M. N. (1994). Styles of inhibiting emotional expression: Distinguishing repressive coping from impression management. *Journal of Personality, 62,* 587-613.

Weinberger, D. A., Schwartz, G. E., & Davidson, R. J. (1979). Low-anxious, high-anxious, and repressive coping styles: Psychometric patterns and behavioral and physiological responses to stress. *Journal of Abnormal Psychology, 88*, 369-380.

Wenzlaff, R. M., & Wegner, D. M. (2000). Thought suppression. *Annual Review of Psychology, 51*, 59-91.

Wessel, I., De Kooy, P. V., & Merckelbach, H. (2000). Differential recall of central and peripheral details of emotional slides is not a stable phenomenon. *Memory, 8*, 95-109.

Widiger, T. A., & Samuel, D. B. (2005). Diagnostic categories or dimensions? A question for the diagnostic and statistical manual of mental disorders. *Journal of Abnormal Psychology, 114*, 494-504.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120,* 3-24.

Wolf, O. T. (2008). The influence of stress hormones on emotional memory: Relevance for psychopathology. *Acta Psychologica, 127*, 513-531.

Wolf, O. T. (2011). Effects of stress on learning and memory: Evidence for sex differences in humans. In C. D. Conrad (Ed.), *The handbook of stress: Neuropsychological effects on the brain.* (pp. 545-559). Chichester, West Sussex, UK: Wiley-Blackwell.

Yantis, S., & Jonides, J. (1990). Abrupt visual onsets and selective attention: Voluntary versus automatic allocation. *Journal of Experimental Psychology: Human Perception and Performance, 16*, 121-134.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18*, 459-482.

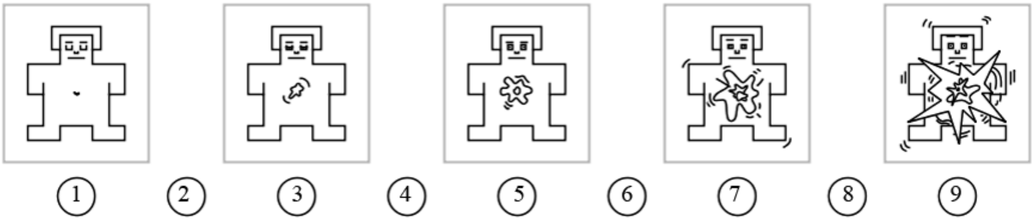
Zhou, P., & Liu, X. (2013). Attentional modulation of emotional conflict processing with flanker tasks. *PloS one, 8*, e60548.

Zimmerman, C. A., & Kelley, C. M. (2010). “I’ll remember this!” effects of emotionality on memory predictions versus memory performance. *Journal of Memory and Language, 62*, 240-253.

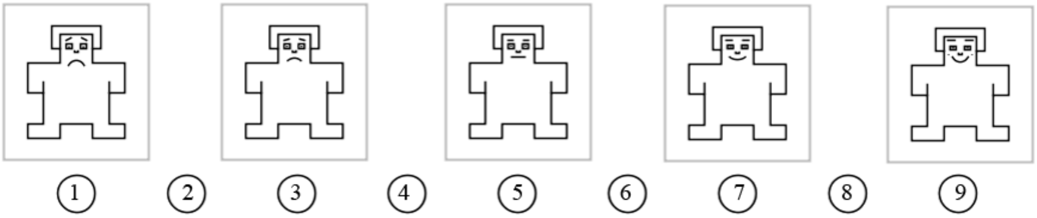
APPENDIX

Appendix 1: Self-Assessment Manikin (SAM) scale to assess arousal and valence in pictures in the norming task

AROUSAL:



VALENCE:



Appendix 2. Preparatory instructions given to participants before consenting to participate in the norming or the main experiment.

I am going to show you some pictures now to give you an idea about the type of material we will be using in the actual experiment. Many of these pictures are designed to arouse a negative emotional response in you (for example, a car accident, war scenes, etc.). Although these pictures have been used in many previous studies, some people may find them distressing and might prefer not to take part. Your participation is entirely voluntary. If you feel that you don't want to look at pictures like this, we can stop right now with no penalty to you. And, even if you do agree now to start looking at these pictures, you are free to stop before the end of the experiment with no penalty—all you have to do is say you want to stop.

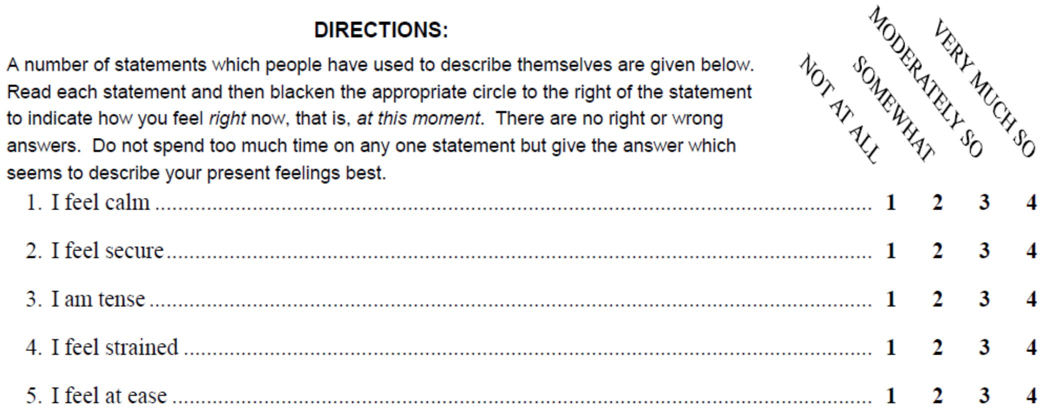
Do you want to continue? [Stop here if they say no.]

I'll show you some example pictures, so you can get a sense of what we're talking about:

Would you like to go on? [Stop here if they say no.]
Please keep in mind that some of the pictures that we show you will depict distressing events, such as acts of violence or trauma. These can be emotionally involving. You may choose not to answer any of the questions that we ask you or even to discontinue participation altogether. The researchers are aware of the sensitive nature of the subject matter addressed in this study and we will fully support your decision. In fact, we encourage you to decline participation in this study if you have recently experienced signs of acute distress, specifically: (1) if you have experienced psychological distress for which you have sought therapy or counseling or (2) if you have been so distressed that you have lost weight, had trouble sleeping, taken continuing medication, or become dependent on alcohol to relieve that distress.

Appendix 3. Questionnaires used in mass-testing for participant pre-selection.

Example items of the State-Trait Anxiety Inventory for Adults (Trait-version) (Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983).



DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then blacken the appropriate circle to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	**1**	**2**	**3**	**4**
2. I feel secure	**1**	**2**	**3**	**4**
3. I am tense	**1**	**2**	**3**	**4**
4. I feel strained	**1**	**2**	**3**	**4**
5. I feel at ease	**1**	**2**	**3**	**4**

Example items of the Balanced Inventory of Desirable Responding (Paulhus, 1991).

Instruction: Please read each statement carefully. Please choose the rating that seems most appropriate to you. Do not spend too much time on any one statement, but give the answer which seems to best describe what is generally true for you.

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

NOT TRUE — SOMEWHAT TRUE — VERY TRUE

1. My first impression of people usually turns out to be right	1	2	3	4	5	6	7
2. It would be hard for me to break any of my bad habits (R)	1	2	3	4	5	6	7
3. I don’t care to know what other people really think of me	1	2	3	4	5	6	7
4. I have not always been honest with myself (R)	1	2	3	4	5	6	7
5. I always know why I like things	1	2	3	4	5	6	7

R = Reverse scored

Appendix 4. Correlations between Subsequent Memory Effects (SME, free recall/confident recognition) and autonomic-response dissociation (ARD), increase in skin conductance level (z-SCL), increase in negative mood in the visual analogue scale (z-VAS).

	Negative Solitary	**Negative with Distractors**	**Neutral Solitary**	**Neutral with Distractors**
		Free recall		
ARD	0.28*	0.03	0.03	0.07
z-SCL change	0.1	0.02	-0.04	0.11
z-VAS mood	0.29*	-0.03	-0.08	0.03
	(*n* = 103)	(*n* = 107)	(*n* = 77)	(*n* = 101)
		Confident recognition		
ARD	0.14	0.09	-0.05	0.12
z-SCL change	0.23†	0.08	-0.03	0.11
z-VAS mood	0.03	-0.05	0.03	-0.05
	(*n* = 102)	(*n* = 107)	(*n* = 106)	(*n* = 107)

*: $p < 0.05$, Bonferroni-corrected; †: $p < 0.05$, uncorrected