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Studying the psychological mechanisms of affective individual differences with EEG correlates

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Institute of Psychology, University of Tartu, Estonia.

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III. Uusberg, A., **Uibo, H.,** Kreegipuu, K., Tamm, M., Raidvee, A., & Allik, J. (2013). Unintentionality of affective attention across visual processing stages. *Frontiers in Emotion Science*, *4*, 969. doi:10.3389/fpsyg.2013.00969

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Contribution of the author

The author of the current dissertation contributed to the publications as follows:

- For **Studies I** and **III**, participated in setting the aims, formulating the research hypotheses, designing the experiment, collecting the data, analyzing the EEG data, and writing the manuscript as a coauthor.
- For **Study II**, set the aims and formulated the research hypotheses, participated in designing the experiment and collecting the data, analyzed the data and wrote the manuscript as the main author.
- For **Study IV**, participated in setting the aims, formulating the research hypotheses, and designing the experiment, analyzed the data and wrote the manuscript as the main author.
- For **Study V**, set the aims and formulated the research hypotheses, participated in designing the experiment and collecting the data, analyzed the data and wrote the manuscript as the main author.

1. INTRODUCTION

The many meaningful ways in which people differ from each-other include relatively stable patterns of affective experiences i.e., affective individual differences. Affective states, such as emotions, moods, stress responses, and motivational impulses help people navigate the environment by eliciting responses to situational demands through "good or bad for me" assessments that lead to the mobilization of cognitive and physiological resources (e.g., Gross, 2014; Scherer, 1984). **Affective individual differences** are dispositional tendencies to experience certain type, intensity, and frequency of affective states (e.g., Reisenzein & Weber, 2009; Scherer, Wranik, Sangsue, Tran, & Scherer, 2004). Clarifying the mechanisms of these predispositions is a vital research goal as many of them relate to important life outcomes, including mental health and well-being (e.g., Brown & Ryan, 2003; Kotov, Gamez, Schmidt, & Watson, 2010; Ozer & Benet-Martínez, 2006). The current dissertation seeks to contribute to the ongoing efforts to uncover the psychological mechanisms of affective individual differences using experimental paradigms and electroencephalographic (EEG) correlates of affective processes. To that end, the dissertation will first present an integrative Construct-Process-Context (CPC) framework and will then demonstrate the applicability of this framework by investigating the psychological mechanisms of three affective individual difference constructs – Neuroticism, mindfulness, and body image.

1.1. Affective individual differences

In the current dissertation, the term "affective individual differences" refers to any individual difference construct that is related to interindividual variation in affective functioning. Affective individual differences include a large category of constructs that cover broad as well as specific and non-clinical as well as clinical variation in affect. The individual difference constructs that are featured in the current dissertation span both dimensions of variance. They range from the broad personality trait of Neuroticism, to the relatively general disposition of mindfulness, to the relatively specific disposition of body image. Each of these phenomena varies in the general population but has also important implications for psychopathology.

Personality can be defined as enduring tendencies to think, feel, and behave in a characteristic way across situations (e.g., Fleeson, 2001; Fleeson & Noftle, 2009; McCrae & Costa, 1999; Pytlik Zillig, Hemenover, & Dienstbier, 2002). According to the influential Five Factor Model (FFM), personality variance is captured in the broad dimensions of Neuroticism, Extraversion, Agreeableness, Openness to Experience, and Conscientiousness (e.g., Costa & McCrae, 1995). Neuroticism is one of the dimensions with particular relevance for affect as its core features include the propensity to experience negative emotions (Allik &

Realo, 1997; Markon, Krueger, & Watson, 2005; Watson & Clark, 1992) as well as the sensitivity to punishments (Corr, DeYoung, & McNaughton, 2013; Elliot & Thrash, 2002, 2010).

Mindfulness is a somewhat more specific affective individual difference construct that is still operative across situations (e.g., Brown & Ryan, 2003; Brown, Ryan, & Creswell, 2007). Dispositional or trait mindfulness describes the naturally occurring tendency to be mindful i.e., in a state of nonjudgmental awareness of present moment experience (e.g., Bishop et al., 2004), and has been linked to reduced emotional reactivity (e.g., Brown, Goodman, & Inzlicht, 2013; Keng, Smoski, & Robins, 2011). The tendency to be mindful, however, can also be increased through practice (i.e., cultivated mindfulness), with similar affective benefits to high trait mindfulness (e.g., Baer, 2003; Hayes & Feldman, 2004; Khoury, Sharma, Rush, & Fournier, 2015).

An example of a relatively specific affective individual difference construct is body image that describes perceptions of and attitudes toward one's appearance. In particular, "negative" or "disturbed" body image has been linked to frequent negative emotions in response to own body (e.g., Cash, Fleming, Alindogan, Steadman, & Whitehead, 2002; Thompson, 2004).

Affective individual differences relate to non-clinical as well as clinical variance in psychological and social functioning. For instance, people with high Neuroticism tend to be less satisfied with their personal relationships, (e.g., Ozer & Benet-Martínez, 2006), use more maladaptive coping strategies (e.g., Carver & Connor-Smith, 2010), and experience greater distress in response to adversities such as physical illness (e.g., Kern & Friedman, 2011). Neuroticism is also associated with elevated risk for psychopathology in general and mood and anxiety disorders in particular (e.g., Kotov et al., 2010; Lahey, 2009; Ormel, Jeronimus, et al., 2013). On the other hand, people with high dispositional mindfulness tend be more resilient (e.g., Conner & White, 2014), use more adaptive coping or emotion regulation strategies (e.g., Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Creswell, Way, Eisenberger, & Lieberman, 2007), and have lower risk for psychopathology (e.g., Brown & Ryan, 2003; Cash & Whittingham, 2010). Similarly to high Neuroticism, disturbed body image is related to depression (Paxton, Neumark-Sztainer, Hannan, & Eisenberg, 2006). It is, however, a particularly strong predictor of unhealthy weight control behaviors (Neumark-Sztainer, Paxton, Hannan, Haines, & Story, 2006) and the development of eating disorders (e.g., Stice, Marti, & Durant, 2011; Williamson, White, York-Crowe, & Stewart, 2004) as well as body dysmorphic disorder (e.g., Veale, 2004).

Described and numerous other associations suggest that affective individual differences can be thought of as either risk factors for or protective factors against psychological and social dysfunctions. To understand, how these effects come about as well as how they could be counteracted or leveraged, it is important to clarify the mechanisms that underlie specific affective individual differences (e.g., Baumert et al., 2017; Depue & Collins, 1999; Ormel, Bastiaansen, et al., 2013). The current dissertation will focus on **psychological**

mechanisms, defined as attributes of psychological processes that contribute meaningfully to the phenotypical expression of the predisposition captured by the individual difference construct.

1.2. Affective states and core affect

Given that affective individual differences reflect interindividual variation in affective states, the search for their psychological mechanisms requires clarification of the concept of affect. To better understand the conceptual space and related disagreements, it helps to look at emotions as prototypical examples of affective states. Despite more than a century of research and academic debate since William James famously asked "What is an emotion" (James, 1884), affective scientists have still not agreed on a unified definition (e.g., Frijda & Scherer, 2009; Izard, 2010). Different accounts range from basic emotion theories that emphasize a limited set of biologically determined states to constructivist theories that view emotions as socially shaped regulatory processes (Gross & Barrett, 2011). Researchers from various backgrounds tend to find some common ground, however, in the functions of emotion as well as it being a multicomponent phenomenon that could be viewed as a dynamic episode (e.g., Izard, 2010; Moors, 2009).

One more or less agreed function of emotion is to help a person navigate the world by monitoring the person-situation transaction and triggering an adaptive response, should an event occur that has relevance for the person's goals (e.g., Izard, 2010; Moors, 2009). The list of components frequently described as being involved in emotion includes (a) a cognitive component (i.e., unconscious or conscious appraisals), (b) a motivational component (i.e., action tendencies or states of action readiness), (c) a behavioral component (i.e., automatic and controlled motor actions, including facial expressions), (d) a neurophysiological component (i.e., changes in central and autonomic nervous system as well as neuroendocrine system), and (e) an experiential component (i.e., the subjective feeling; e.g., Frijda & Scherer, 2009; Moors, 2009). Many theories also agree that emotions can be thought of as dynamic episodes that evolve over time (e.g., Moors, 2009). For instance, according to the modal model of emotion, an emotion episode involves paying attention to potentially salient aspects of the situation (both external and internal i.e., environmental cues as well as sensations and thoughts), evaluating these aspects in light of active goals, and launching a multicomponent response (Barrett, Ochsner, & Gross, 2007; Gross, 1998, 2007, 2014). In addition to integrating the components of emotion described above, the modal model highlights the role of attention in an emotion episode.

Many features of emotions also characterize other phenomena in the general class of affective states. All affective states can be viewed as multicomponent processes involving a person-situation transaction that unfolds over time with the function to navigate the world in light of salient goals (e.g., Gross, 2014;

Scherer, 1984). However, affective states also differ in several important ways, including the predominance of and the coherence between different components, their sensitivity to situational factors, and their timescale (e.g., Frijda & Scherer, 2009; Scherer, 2005). Emotions have a strong situational focus, meaning that they are elicited by a distinct external (e.g., a loud noise) or internal (e.g., an upsetting memory) trigger. They unfold rapidly, are relatively short-lived, and tend to be more intense than other affective states. Emotions also tend to involve most of the components described above that can become highly synchronized (Frijda & Scherer, 2009; Scherer, 2005). Motivational impulses are similar to emotions in the sense that they too direct and energize specific responses to the environment in a relatively short time-frame, but they have a narrower range of triggers and are more directly affected by the current state of the body (Ferguson, 2000; Gross, 2007). Moods are more diffuse, less intense, and longer lasting than emotions and have a less apparent situational cause. They can give rise to broad action tendencies and behavioral patterns, but alter mainly subjective experience and cognition (Gross, 2014; Parkinson, Totterdell, Briner, & Reynolds, 1996; Scherer, 2005). Stress typically refers to unspecified negative affect elicited by the perceived inability to deal with situational demands that leads to changes in physiology and subjective experience. Depending on the timescale of the taxying circumstances, stress can be either acute or chronic (e.g., Kemeny, 2003; Lazarus, 1993; Lazarus & Folkman, 1984).

In addition to their episode-like and multicomponent nature, all affective states are characterized by core affect, defined as a general state of pleasure or displeasure with some degree of arousal (e.g., Russell, 2003; Russell & Barrett, 1999). Core affect can be schematically represented as a point in a two-dimensional space referred to as the affective circumplex (e.g., Russell, 1980; Russell & Barrett, 1999). The typical dimensions of the circumplex are hedonic valence and arousal (e.g., Russell & Barrett, 1999), corresponding to the "good or bad for me" assessment and related activation, respectively. Alternative dimensions have also been used to define the affective space, including positive and negative affect (e.g., Watson & Tellegen, 1985) and approach and withdrawal/avoidance (e.g., Davidson, 1992c). Importantly, these and other candidate dimensions can be incorporated into one circular structure (Yik, Russell, & Barrett, 1999), validating the general principle of two-dimensional core affect.

Core affect captures the essence of affective states by representing the person-situation relationship. It can be thought of as a "neurophysiological barometer" that signals one's standing in relation to the world at any given moment (Barrett & Bliss-Moreau, 2009). From the mechanistic perspective, however, it is important to ask how core affect (and by extension any affective state) helps the person to navigate the world. In general, changes in core affect modulate the person-situation transaction by readying the organism for an appropriate response. For instance, affective arousal is related to sympathetically mediated metabolic changes that mobilize the organism's resources for action (e.g., Lang & Bradley, 2010, 2013). More importantly for the current dissertation, these preparatory dynamics entail also several psychological aspects.

One important psychological function of core affect is signaling the broad direction of an appropriate response by activating **approach or avoidance motivation** (e.g., Harmon-Jones, 2003; Norris, Gollan, Berntson, & Cacioppo, 2010). Motivational direction is associated with the position of the core affect "barometer reading" within the affective circumplex (e.g., Russell & Barrett, 1999; Yik et al., 1999). Moving diagonally from low arousal negative to high arousal positive states corresponds to increasing approach motivation, whereas moving diagonally from low arousal positive to high arousal negative states corresponds to increasing avoidance motivation[1]. Functionally, the activation of motivational tendencies serves the broad goal of escaping threats and other punishments as well as obtaining nourishments and other rewards (e.g., Barrett & Bliss-Moreau, 2009).

Another important psychological function of core affect is guidance of information processing. Regardless of the direction of the required response, affect has been shown to increase attention allocation and information intake (e.g., Lang & Bradley, 2010, 2013). This phenomenon, whereby both positive and negative affectively salient stimuli are processed in a prioritized manner, has been termed **motivated attention** (Lang, Bradley, & Cuthbert, 1997) but is referred to also as **emotional attention** (e.g., Vuilleumier, 2005) or **affective attention** (e.g., Uusberg, 2014). The preferential processing of affective stimuli has been conclusively demonstrated in a large body of studies using behavioral, physiological, as well as neuroimaging measures (e.g., Lang & Bradley, 2010; Pourtois, Schettino, & Vuilleumier, 2013; Vuilleumier, 2005). Importantly, motivated attention can be characterized by relatively automatic and fast as well as more controlled and sustained prioritization of affectively salient information (e.g., Schupp, Flaisch, Stockburger, & Junghöfer, 2006). The overarching function of motivated attention, regardless of automaticity, is to clarify the circumstances of the potentially relevant situation and provide input for an appropriate response (e.g., Lang & Bradley, 2013).

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[1] One exception to that parallel is anger as it is characterized by high arousal negative affect but has been linked to approach motivation (e.g., Carver & Harmon-Jones, 2009). To overcome the directional inconsistencies, sometimes appetitive and defensive motivation is used instead of approach and avoidance motivation (e.g., Lang & Bradley, 2013).

1.3. Mechanisms of affective individual differences

A good starting point for clarifying the psychological mechanisms of affective individual differences is to look for interindividual variations in the psychological processes that are involved in affective states such as the above-described approach-avoidance motivation and motivated attention. Both approach-avoidance motivation and motivated attention can be mechanistically involved in affective individual differences, including the ones featured in the current dissertation. For instance, high Neuroticism has been associated with increased avoidance tendencies (e.g., Elliot & Thrash, 2002, 2010), greater mindfulness with reduced prioritization of highly arousing affective cues (e.g., Brown et al., 2013), and disturbed body image with increased prioritization of appearance information (e.g., Rodgers & DuBois, 2016).

Researchers interested in interindividual variation in affective processes often make use of their neurophysiological markers, including different EEG correlates. For instance, variations in motivational tendencies can be inferred from asymmetrical anterior brain activity such as anterior EEG asymmetry (e.g., Harmon-Jones & Gable, 2018). The premise of anterior EEG asymmetry is that relatively more activity over left anterior regions (i.e., left-sided anterior EEG asymmetry) is associated with greater approach motivation and relatively more activity over right anterior regions (i.e., right-sided anterior EEG asymmetry) is associated with greater avoidance motivation (e.g., Davidson, 1984, 1992a; Harmon-Jones & Allen, 1998)[2]. Differences in motivated attention, on the other hand, can be assessed with numerous markers of attentional biases and/or sensory processing (e.g., Pourtois et al., 2013; Vuilleumier, 2005), including EEG event-related potential (ERP) components that have been shown to be modulated by affectively salient stimuli (Hajcak, Weinberg, MacNamara, & Foti, 2011; Olofsson, Nordin, Sequeira, & Polich, 2008; Pourtois et al., 2013; Schupp, Flaisch, et al., 2006)[3].

Studying psychological mechanisms of affective individual differences through neurophysiological correlates helps to reduce the confounding effects of demand characteristics and to overcome cognitive accessibility issues. However, it also introduces a conceptual challenge of how to best relate the correlates of the psychological processes and the affective individual difference constructs of interest. The current dissertation offers an integrative framework as an option for tackling this problem. The proposed framework relies on a number of conceptual advances that are first illustrated by considering studies using anterior EEG asymmetry as a correlate of approach-avoidance motivation.

There are two main traditions of linking anterior EEG asymmetry with affective individual difference constructs. One focuses on resting state brain

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2 Anterior EEG asymmetry as a measure of approach-avoidance motivation is described in greater detail in Section 2.

3 The ERP components that are modulated by motivated attention are described in greater detail in Section 3.

activity (i.e., anterior EEG asymmetry activity) and the other on changes in brain activity during experimental tasks (i.e., anterior EEG asymmetry activation; Reznik & Allen, 2018). This distinction mirrors two broad ways of studying the mechanisms of individual differences using functional correlates of nervous system activity. Resting state measures aim to uncover stable features of central or peripheral physiology that would relate to and help understand affective individual differences on a general level. For instance, relatively right-sided resting state anterior EEG asymmetry has been frequently associated with depressive symptoms as well as elevated risk for depression (e.g., Thibodeau, Jorgensen, & Kim, 2006), suggesting that variations in baseline motivational tendencies may be implicated in depression and may precede the development of the condition. In contrast, task-based measures aim to clarify how individual differences relate to specific processes and therefore focus on the dynamics of nervous system activity during experimentally manipulated conditions. For instance, relatively right-sided anterior EEG asymmetry elicited by public negative feedback has been linked to trait anxiety (Crost, Pauls, & Wacker, 2008), suggesting that anxious individuals experience greater activation of avoidance motivation during socially threatening situations.

The use of resting state measures can be conceptually linked to trait theories that emphasize the decontextualized aspects of individual differences i.e., how predispositions relate to behavior and affect across a variety of situations (e.g., Stemmler & Wacker, 2010). Resting state measurement settings are therefore deliberately void of stimulation or manipulations with the hope that an "idling" brain reveals universal aspects of its' functioning. However, extensive neuro-imaging work suggests that equating the resting state measurement with neural idling may be unfounded (e.g., Morcom & Fletcher, 2007; Raichle & Snyder, 2007). Studies using Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI) have revealed a default mode network (DMN) or task-negative network that shows increased activity during rest and decreased activity during cognitive tasks (e.g., Greicius, Krasnow, Reiss, & Menon, 2003; Raichle, 2015). Activity in the DMN, however, has been associated, among other things, with self-referential and conceptual processing (e.g., Binder et al., 1999; McKiernan, Kaufman, Kucera-Thompson, & Binder, 2003). This suggests that while there can be systematic and meaningful inter-individual variations in functional neural correlates measured at rest, these may, to varying degree, arise from spontaneous "tasks" that people engage in, rather than from some basic feature of the brain functioning.

It is often also assumed that the spontaneous activity/processing that accompanies resting state recording functions as a projective test and therefore reveals underlying "natural" inclinations. However, because there is little control over the processing that occurs under these conditions, the emerging patterns are often difficult to interpret and the error variance is large (e.g., Coan, Allen, & McKnight, 2006). Furthermore, idiosyncratic reactions to the recording environment may constitute important confounds that can even interact with the individual difference constructs of interest in unpredictable ways. For instance, both the subjective unpleasantness of EEG cap preparations (Blackhart, Kline, Donohue, LaRowe, & Joiner, 2002) and the perceived attractiveness of the experimenter (Wacker, Mueller, Pizzagalli, Hennig, & Stemmler, 2013) have been shown to moderate resting state anterior EEG asymmetry findings.

There are also numerous empirical inconsistencies in the literature regarding the relationship between resting state anterior EEG asymmetry and affective individual difference constructs, supporting the notion that resting state measures may have notable restrictions. For instance, although it is widely assumed that relatively more right-sided anterior EEG asymmetry covaries with depression, there are nevertheless many failures to replicate this finding (e.g., Harmon-Jones et al., 2002; Nitschke, Heller, Palmieri, & Miller, 1999; Reid, Duke, & Allen, 1998). Furthermore, the evidence for associations is even more inconclusive for other constructs that are theoretically also related to approach-avoidance motivation (e.g., Harmon-Jones & Gable, 2018; Wacker, Chavanon, & Stemmler, 2010). The difficulties in establishing connections between resting state brain activity and self-reported individual differences are not limited to anterior EEG asymmetry. The broader issue was exemplified, for instance, in a study demonstrating that neither the scores of FFM personality dimensions nor subordinate aspect factors (e.g., DeYoung, Quilty, & Peterson, 2007) were predictable from the power spectra of the resting state EEG data using machine learning algorithms (Korjus et al., 2015).

Given the numerous limitations of resting state measures, several authors have advocated for using task-based measures of nervous system activity to establish the mechanism of affective individual differences. For instance, the capability model of anterior EEG asymmetry proposes that meaningful inter-individual variation in anterior EEG asymmetry is best detectible during emotional challenges that put a demand on underlying motivational systems (Coan et al., 2006). Similarly, the interactionistic approach to personality-physiology relationships suggests that the associations between personality traits and physiological functioning are moderated by situational factors and person's idiosyncratic appraisals of these factors. Therefore, trait-relevant experimental conditions should be used when studying the physiological under-pinnings of personality (Stemmler & Wacker, 2010).

In support of the task-based approach, many studies have demonstrated stronger relationships between anterior EEG asymmetry and theoretically linked individual difference constructs during emotionally evocative conditions compared to resting state (e.g., Allen & Reznik, 2015; Coan et al., 2006; Meyer et al., 2017; Stewart, Coan, Towers, & Allen, 2014). The advantages of task-based approach extend beyond anterior EEG asymmetry. For instance, there is some preliminary evidence that machine learning algorithms might also be able to predict personality more reliably from EEG data recoded during specific experiments (e.g., Pisarchik et al., 2018). Not to mention that for many affective processes, including motivated attention (e.g., Lang & Bradley, 2010; Pourtois et al., 2013; Vuilleumier, 2005), the task-based approach is an inherent part of the evaluation procedure.

By utilizing the basic principles of experimental psychology, the task-based approach offers control over the state of the participant during the recording and allows to make more precise inferences about the causes of differences in activity/activation as well as psychological processes that might be implicated. These methodological considerations make the task-based approach relevant for studying the mechanisms of affective individual differences regardless of whether they are conceptualized as general traits or situation-dependent characteristics. However, the benefits of task-based measures go beyond reducing vulnerability to state confounds.

Another important benefit of the task-based approach is that it allows to systematically manipulate contextual features. Doing so may help reveal more specific mechanisms of affective individual differences. For instance, it has been hypothesized that greater amygdala reactivity (a neural marker of motivated attention; e.g., Vuilleumier, 2005) contributes to individual differences in negative affectivity, such as Neuroticism (e.g., Ormel, Bastiaansen, et al., 2013). The findings linking Neuroticism with amygdala reactivity to negative stimuli, however, are inconclusive (e.g., Kennis, Rademaker, & Geuze, 2013; Servaas et al., 2013). There is some evidence that the mixed pattern of results may stem from unaccounted contextual moderators. Namely, a recent study found that high Neuroticism was related to stronger amygdala response to fearful facial expressions only after stress induction (Everaerd, Klumpers, van Wingen, Tendolkar, & Fernández, 2015). This suggests that Neuroticism-related sensitivity to negative cues may be stress-dependent. Meanwhile, obsessive compulsive disorder (OCD) related differences in the processing of negative stimuli seem to depend on contextual certainty. Compared to heathy controls, people diagnosed with OCD have been shown to exhibit increased prioritization of uncertain negative stimuli (Dieterich, Endrass, & Kathmann, 2017).

Contextual manipulations have elucidated also the psychological mechanism of other types of affective individual differences. For instance, it has been suggested that people with eating disorders process disorder relevant stimuli, including food cues, in a prioritized manner (e.g., Aspen, Darcy, & Lock, 2013; Faunce, 2002). For restrained eaters, however, the prioritization of food cues may depend on food availability. Specifically, their reactivity has been shown to be attenuated in response to cues of available foods, potentially due to greater regulatory abilities (Blechert, Feige, Hajcak, & Tuschen-Caffier, 2010).

There is also evidence that context may play an important role in the mechanisms of affective individual differences involving the activation of approach-avoidance motivation. A recent study demonstrated that depending of the contextual signals of negative social stimuli, the anterior EEG asymmetry response was differentially related to the personality dimensions of Antagonism and Detachment (Papousek et al., 2018). Specifically, higher Antagonism was related to relatively stronger approach motivation in response to auditory cues of confrontation (i.e., aggressive voices) and higher Detachment was related to relatively stronger avoidance motivation in response to auditory cues of desperation (i.e., crying). Neither of the dynamics would have been revealed during resting state EEG recordings or during more generic negative affect elicitation.

The existing body of research suggests that both the task-based approach and the consideration of contextual factors can offer important benefits for studying the psychological mechanisms of affective individual differences. However, the evidence supporting this insight is scattered between different research domains and methods. The current dissertation will therefore propose an integrated and domain-general conceptual framework that can be used to systematize existing evidence as well as plan future empirical research. After the description of the framework the dissertation elaborates further on its' theoretical origins and then demonstrates its' applicability by investigating first the motivational and then the attentional mechanisms of selected individual difference constructs.

1.4. The Construct-Process-Context framework

The current dissertation proposes the Construct-Process-Context (CPC) framework as an approach for studying the psychological mechanisms of affective individual differences. The framework builds on the interactionistic models of trait-physiology relationship (e.g., Coan et al., 2006; Stemmler & Wacker, 2010) as well as cognitive-affective experimental psychology. The central premise of the CPC framework is that the psychological mechanisms of affective individual difference constructs often involve certain affective processes becoming altered in a context-dependent manner. The framework thus proposes that determining the psychological mechanisms of affective individual differences requires simultaneous consideration of construct-relevant affective processes and construct-relevant contextual factors. More specifically, it suggests that the psychological mechanisms lie at the intersection of processing biases and contextual demands with theoretically determined significance for the construct-related phenotypical variation. The framework also emphasizes the use of experimental designs that capture the interplay between the affective process and the context in a controlled manner, preferably by using objective markers of the process. Because CPC assumes interactions between all the components of the studied psychological mechanism – construct, process, and context – it can be considered a systemic approach (e.g., Barnard & Teasdale, 1991).

The main body of the dissertation focuses on the potential mechanisms of affective individual differences that involve either the activation of approach-avoidance motivation or motivated attention, measured with EEG correlates. However, the CPC framework could be applied to different processes using different methods and is therefore first described in a general manner.

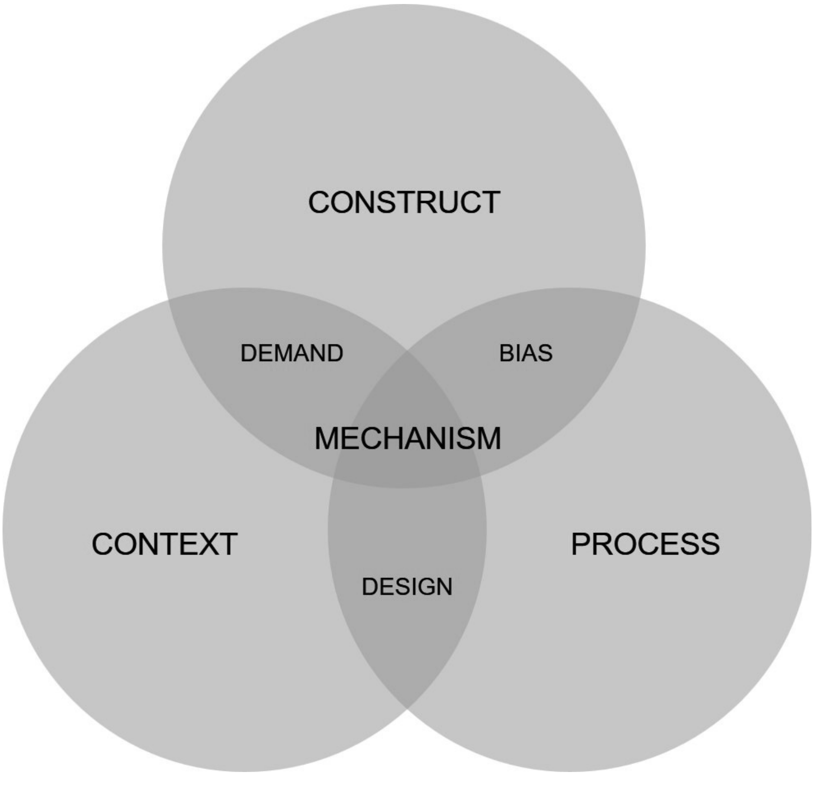

Figure 1. Schematic representation of the Construct-Process-Context (CPC) framework for studying the psychological mechanisms of affective individual differences. CPC has three main elements: **construct**, **process**, and **context**; three interactional nodes: **bias**, **demand**, and **design**; and a central dynamic that is the **mechanism** (definitions and explanations for each element are provided in the text). The diagram depicts the interplay between the elements, illustrating how specific psychological mechanisms are best detectable at the intersection of construct-relevant processing biases and contextual demands using experimental designs that capture the interaction between the process and the context of interest in a controlled manner.

Figure 1 is a schematic representation of the CPC framework. In the figure, **mechanism** refers to any psychological mechanism implicated in the individual difference construct of interest. As described earlier (see section 1.1.), a psychological mechanism is defined here as any attribute of a psychological process that contributes meaningfully to the phenotypical expression of the predisposition. The three core elements of CPC – construct, process, and context – form the broad conceptual space for studying the psychological mechanisms. Given that the dissertation focuses on affective individual differences, the space will be limited to processes and contexts that are related to variations in affect, although the same principles may apply to other phenomena.

When used as a noun, the term construct can in general be defined as a phenomenon that is not directly observable but instead inferred from data (i.e., hypothetical construct; VandenBos, 2015). In the CPC framework, however, the label **construct** refers specifically to the affect-related individual difference construct of interest (e.g., Neuroticism). The CPC framework is meant to be applicable to a range of affective individual differences regardless of whether they are general or specific, innate or acquired, lasting or transient. The use of the broad term "construct" serves the goal of emphasizing that all such individual differences can be viewed as hypothetical entities. The CPC framework could therefore be used to conceptualize the psychological mechanisms of personality traits, a manic episode of the bipolar disorders, as well as context-dependent social anxiety such as fear of public speaking. The latter will be used as an example for describing the framework.

Process refers to an affective process that could be implicated in producing the construct-related phenotypical variation (e.g., differences in overt behavior or affective experiences). It could therefore be thought of as a psychological "tool" or "device" that generates and modulates the affective states in which individual differences manifest. In the CPC framework, an affective process can be any component of an affective episode, including attention allocation, cognitive evaluation/appraisal, and motivational response[4]. To avoid circularity, however, it is important to maintain separation between the affective process and the phenotypical expression of the construct of interest (e.g., the subjective feeling component may not be well-suited to explain mechanistically individual differences in Neuroticism). When determining the potential psychological mechanisms, empirical findings and theoretical models of similar constructs provide an informative starting point. Many affective individual differences in the anxiety domain have been associated with changes in motivated attention (e.g., Cisler & Koster, 2010). Therefore, it would be reasonable to assume that attention allocation is also implicated in the example case of fear of public speaking.

Context refers to situational factors that are relevant for revealing inter-individual variance along the construct of interest. In case of fear of public speaking, the context space would constitute various situations related to public speaking (e.g., preparation or anticipation of a speech, receiving feedback to a speech). Importantly, the context need not be limited to objective aspects of the situation or features that are external to the person. It could also entail the subjective interpretation of the situation (e.g., the personal relevance of the speech) as well as the goals that are active in that situation (e.g., focus on the presentation time-limit vs. the content). To maximize the empirical utility of the

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[4] Depending on the classification, the components of an affective episodes could be categorized as cognitive, motivational, physiological etc. What makes them affective processes for the purposes of the CPC framework is that they are implicated in the unfolding of an affective episode and aid with the function of affect to navigate the environment in light of salient goals (see also Section 1.2.).

CPC framework, it is advisable to identify a small number of contextual features with high relevance for the construct of interest that can be manipulated in a controlled manner.

The CPC framework goes on to suggest that specific and interpretable psychological mechanisms of affective individual differences can be understood by clarifying the interplay between the three core elements. This entails conceptualizing the three junction nodes of the framework – bias, demand, and design.

Bias is the relationship between the construct and the process. It refers to a systematic alteration in the affective process that is implicated in the individual difference construct. Note that in the CPC framework, bias has a neutral meaning and refers to any tendency or inclination irrespective of whether it is desirable or undesirable (i.e., the 2nd meaning in VandenBos, 2015). Depending on the context and the individual difference construct, the bias can be an adaptive or maladaptive alteration in the process. The conceptualization of the specific bias helps to determine whether a given affective process is a likely candidate for the psychological mechanism of the particular construct. Only processing biases that could be involved in producing phenotypical variation should be considered. For instance, in case of attention allocation and fear of public speaking, selective attention to negative information could increase anxiety and foster the prototypical avoidance behavior (American Psychiatric Association, 2013).

Demand is the interplay between the construct and the context. It refers to the differential challenges that specific contexts impose on someone depending on where they fall on the individual difference spectrum. For instance, expressing an idea to others is a potentially challenging situation that can reveal individual differences in social anxiety. The particular demands of that situation, however, vary depending on the degree and type of social anxiety. For a student with specific fear of public speaking, presenting a topic to the whole class can be very anxiety provoking but they might be at ease with discussing the same topic in a small group. A student with general social anxiety, however, might find both situations frightening, whereas a student with low anxiety might feel equally relaxed in both situations. Therefore, when the goal is to study the psychological mechanisms of fear of public speaking, focusing on the difference between socializing in a group and giving a presentation might be particularly useful. The demand component of the CPC framework can be further broken down according to more specific contextual features such as the size of the group (small vs. large), the nature of the interaction (recreational vs. professional), and the outcome (e.g., feedback).

Finally, **design** refers to the experimental operationalization of the interplay between the affective process and the contextual factors, encompassing both dependent (e.g., the measures of the process) and independent variables (e.g., stimuli and tasks). An experimental design is suitable for studying the psychological mechanisms of an affective individual difference construct if it allows to reliably elicit and measure interindividual variance and biases in the process of interest. For instance, if the goal is to determine whether selective attention to negative feedback is a potential psychological mechanism of fear of public speaking, then the experimental design could entail tracking of eye-movements while participants with high and low anxiety read feedback to their presentation containing both positive and negative emphases as opposed to similarly valanced comparison text.

1.5. Similarities and differences with other frameworks

The CPC is an attempt to integrate other theories and general research practices into a unitary conceptual framework that would serve as an aid for planning and conducting studies on the psychological mechanisms of various affective individual differences. Among others, the CPC framework is related to many of the ideas and principles featured in the Research Domain Criteria project (RDoC) that in turn is influenced by the broad fields of clinical neuroscience, cognitive-affective neuroscience, and experimental psychology. The goal of RDoC is to provide unified principles and terminology for systematizing behavioral and neuroscientific research on psychopathology. It proposes a conceptual matrix that lists suggested research targets and units of analysis for describing dimensionally normal as well as pathological functioning. The targets are basic domains of human functioning that are rooted in distinct neural circuits (e.g., attention, cognitive control, reward learning, biological rhythms). The units of analysis are the activity of these circuits, as well as their antecedents (i.e., genes, molecules, and cells that comprise the circuits) and resulting dynamics (i.e., physiology, behavior, self-reported experiences). When applicable, the RDoC matrix also lists recommended experimental paradigms and measures (e.g., Cuthbert, 2014; Morris & Cuthbert, 2012). The similarities between the CPC and the RDoC framework include the preference of objective measures and task-based approaches (i.e., the design node of the CPC framework and recommended paradigms in the RDoC matrix). Both frameworks also assume that individual differences are rooted in certain alterations in functioning (i.e., the process and bias nodes in the CPC framework and the research domains in the RDoC matrix). The main difference is that RDoC does not emphasize the role of context. It stresses the importance of experimental control but not experimental manipulation of contextual features. De-emphasizing the role of context in individual differences may partly originate from the tradition of studying decontextualized biomarkers and endophenotypes (e.g., Gottesman & Gould, 2003; Lenzenweger, 2013). However, the evidence presented in Section 1.3. suggests that considering contextual demands may be important for understanding more specific functional mechanisms of affective individual differences.

Several other theoretical accounts are more closely related to CPC in their acknowledgement of context. In particular, the capability model of individual differences in anterior EEG asymmetry (Coan et al., 2006) and the broader interactionistic approach to personality-physiology relationships (Stemmler & Wacker, 2010), described briefly in Section 1.3. Both highlight the role of context and contextual demands in two ways. First, they view manipulation of context as essential for activating the (neuro)physiological systems that are theoretically implicated in affective individual differences. Second, they emphasize the need to assess and exert control over contextual features that might overwise confound the individual difference findings. The two frameworks differ from CPC, however, in their theoretical goal. Unlike CPC, they focus primarily on the biological mechanisms or biological correlates of individual differences and do not emphasize the potential implications for phycological processes (Coan et al., 2006; Stemmler & Wacker, 2010). This is a conceptual divergence from the CPC framework, where the focus is on the psychological processes and changes in (neuro)physiology are viewed simply as objective measures of these processes.

The CPC framework is also related to interactionistic resolutions to the broader person-situation debate in the personality literature (e.g., Baumert et al., 2017). At the root of the debate lies the question whether behavior is determined mainly by stable and global person-related factors (i.e., trait theories; e.g., McCrae & Costa, 1999) or dynamic and specific situational factors (i.e., social-cognitive theories; e.g., Mischel & Shoda, 1995). Interactionism takes the middle road by emphasizing the interplay between the two sources of variance (e.g., Endler & Magnusson, 1976; Funder, 2006). It is important to note, however, that the general principles of interactionism are rather universal and are featured even in the most radical trait-theories. For instance, the FFM acknowledges interactions between basic tendencies and the environment, expressed in what is called characteristic adaptations (e.g., McCrae & Costa, 1999).

The idea that behavior should be viewed as a function of the person and the situation was first proposed by Kurt Levin (Lewin, 1936) and is summarized in this well-known formula: B = f (P, S). David C. Funder later labelled the three elements of the formula – persons (P), situations (S), and behaviors (B) – as the personality triad and proposed that the best way to understand each element is in terms of the interplay between the other two (Funder, 2006, 2009). The personality triad idea is relevant for the CPC framework because the construct, the context, and the process could be viewed as specific versions of persons, situations, and behaviors, respectively. Funder proposes that "[…]a good way to describe a person psychologically might be in terms of the behaviors he or she performs and the situations in which he or she performs them" (Funder, 2009, p. 123). This suggestion implies that on a different level of abstraction a specific affective predisposition that characterizes a person (i.e., an affective individual difference construct) could be described in terms of the psychological processes that are involved and the contexts where they operate.

Another relevant interactionistic approach to individual differences is the capability model of personality that views individual differences as sets of abilities and proposes that they should be evaluated similarly to mental and physical abilities by imposing contextual demands as targeted tests (Wallace, 1966). The CPC framework views individual differences more broadly, as predispositions describing probabilistic tendencies to experience certain behaviors and affective states (e.g., Fleeson, 2001; Fleeson & Noftle, 2009). The CPC framework shares, however, the capability models' emphasis on targeted tests, viewing contextual demands as valuable means to reveal related dynamics in a controlled manner.

In a way the CPC framework is situated between the broad interactionistic approaches to person-situation relationships and the specific interactionistic approaches to personality-physiology relationships. The former focus on the phenotypical expression of the individual difference construct, the latter focus on the biological mechanisms or correlates, and the CPC focuses on the psychological mechanisms.

It is important to note, that the CPC framework does not claim that all mechanisms of affective individual differences are psychological or that all psychological mechanism are necessarily contextual. Depending on the construct there may be numerous biological as well as context-independent mechanisms. It simply summarizes the idea that in order to establish potential psychological mechanism of affective individual differences, the role of contextual factors should be carefully considered and/or systematically manipulated.

1.6. Aims and hypotheses

The general aim of the current dissertation was to test the applicability of the CPC framework by demonstrating how careful operationalization of theoretically motivated processing biases and contextual demands helps to improve the understanding of specific psychological mechanisms of a range of affective individual difference constructs. To that end the potential motivational or attentional mechanisms of Neuroticism, preoccupation with body image, and mindfulness were investigated in Studies II, IV, and V, respectively. Studies I and III of the dissertation clarified open methodological questions to inform the design and interpretation of the individual difference studies.

The dissertation first gives an overview of anterior EEG asymmetry as a measure of approach-avoidance motivation and then describes two related empirical studies. The specific aim of Study I was to clarify whether standardized affective images (e.g., Lang, Bradley, & Cuthbert, 2008) could be used to explore individual differences in anterior EEG asymmetry activation. In Study II the CPC framework was applied to clarify the motivational mechanisms of Neuroticism. The results of Study I indicated that affective images may not be suited for studying interindividual variations in approach-avoidance motivation with anterior EEG asymmetry. Therefore, Study II used social contact with a real person as a novel and motivationally more activating Neuroticism-relevant context. The specific aim of Study II was to investigate whether the theoretically proposed but empirically elusive avoidance tendency is activated in participants with high Neuroticism while being the target of another person's attention, manipulated with gaze direction.

The dissertation then turns to motivated attention by first introducing earlier and later ERP correlates of the process and then presenting three additional empirical studies. The specific aim of Study III was to clarify the automaticity of motivated attention by evaluating the effects of unintentional vs. intentional processing of affective meaning across different processing stages. The dissertation then illustrates how the CPC framework could be used to conceptualize and study the specific attentional mechanisms of affective individual difference constructs. Study IV focused on preoccupation with body-image (Akkermann, 2010), which is the cognitive-affective component of disturbed body image (e.g., Cash, 2004; Cash & Brown, 1987; Thompson, 2004). The specific aim of Study IV was to test whether automatic and controlled prioritization of body size is differentially modulated in women with high and low preoccupation, depending on whether they are evaluating their own body (i.e., the self-observation context) or the body of a peer (i.e., the social comparison context). Finally, Study V explored the mechanisms of mindfulness by focusing on cultivated mindfulness. The specific aim of Study V was to test whether mindfulness is related to increased affective adaptation, characterized by gradual reduction in the preferential processing of negative stimuli over time. To imitate the cultivation process, mindfulness was experimentally manipulated as a state in novice participants while they repeatedly viewed affective images. Self-reported dispositional mindfulness was also assessed and related to the dynamics of manipulated mindfulness state.

2. APPROACH-AVOIDANCE MOTIVATION AND ANTERIOR EEG ASYMMETRY

The affective-motivational model of asymmetrical anterior brain activity as measured with EEG was first proposed by Richard J. Davidson (e.g., 1984, 1992a, 1995). He suggested that relatively left-sided anterior EEG asymmetry (i.e., more activity recorded over left frontal regions) is related to positive emotions and approach motivation, whereas relatively right-sided asymmetry (i.e., more activity recorded over right frontal regions) is related to negative emotions and withdrawal/avoidance motivation[5]. Importantly for the current dissertation, Eddie Harmon-Jones and John J. B. Allen (1998) demonstrated that anterior EEG asymmetry captures primarily the motivational tendencies not the valence of affective experiences. They did so by linking anger, a negative but typically approach-oriented emotion, to relatively left-sided asymmetry. Over time, the motivational focus has become increasingly prevalent in anterior EEG asymmetry literature (Harmon-Jones, 2003; Harmon-Jones & Gable, 2018; Harmon-Jones, Gable, & Peterson, 2010; Rodrigues, Müller, Mühlberger, & Hewig, 2018). Therefore, current dissertation views relatively more right-sided anterior EEG asymmetry as a marker of approach motivation and relatively more left-sided anterior EEG asymmetry as a marker of avoidance motivation.

Anterior EEG asymmetry is typically measured as the difference in log-transformed alpha band (8-13 Hz) power between homologous right and left electrodes (ln[right alpha)-ln[left alpha]) over midfrontal (F4/F3) and lateral frontal (F6/F5, F8/F7) sites (Allen, Coan, & Nazarian, 2004; Reznik & Allen, 2018; Smith, Reznik, Stewart, & Allen, 2017). The premise of anterior EEG asymmetry is that alpha power is inversely related to regional brain activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Davidson, Chapman, Chapman, & Henriques, 1990). Therefore, higher alpha asymmetry scores are interpreted as evidence for relatively greater left frontal activity and lower scores as evidence for relatively greater right frontal activity.

As described in Section 1.3., two indicators of anterior EEG asymmetry can be differentiated: activity and activation. Activity refers to the level of anterior EEG asymmetry recorded during a given period whereas activation refers to a change in anterior EEG asymmetry in response to specific stimuli or more general affect manipulation (Smith et al., 2017). Anterior EEG asymmetry activity, when recorded at rest, is thought to capture a trait-like predisposition to

[5] Davidson used the term withdrawal motivation, emphasizing the link between active avoidance and right-sided anterior EEG asymmetry. However, some later theories have linked right-sided anterior EEG asymmetry to behavioral inhibition or passive avoidance (e.g., Gable, Neal, & Threadgill, 2018; Wacker, Chavanon, Leue, & Stemmler, 2008). To cover both active and passive avoidance tendencies the term avoidance motivation will be used instead of withdrawal motivation in the current dissertation. The use of avoidance motivation instead of withdrawal motivation also helps to disambiguate the motivational tendency form the Withdrawal aspect factor of Neuroticism examined in Study II.

experience approach or avoidance related affect (i.e., "the affective style"; Davidson, 1992b, 1998). Anterior EEG asymmetry activation, however, is thought to reflect acute affective-motivational responses (e.g., Harmon-Jones, 2003; Harmon-Jones & Gable, 2018; Reznik & Allen, 2018).

The idea that anterior cortical regions are asymmetrically involved in affect originates from studies associating injuries to the left frontal cortex with increased depressive symptoms and injuries to the right frontal cortex with increased manic symptoms (e.g., Gainotti, 1972; Goldstein, 1939; Robinson & Price, 1982). The focus on difference scores stems from the assumption that one hemisphere (or specific regions in one hemisphere) is inhibiting the other. Namely, early studies demonstrated that suppressing the activity of left or right hemisphere with amytal injection (i.e., the Wada test), thereby supposedly releasing the contralateral hemisphere from inhibition, induced depressed and euphoric mood, respectively (Alema, Rosadini, & Rossi, 1961; Perria, Rosadini, & Rossi, 1961; Terzian & Cecotto, 1959). Some later studies have conceptually replicated this modulatory effect using repetitive Transcranial Magnetic Stimulation (rTMS; e.g., Schutter, van Honk, d'Alfonso, Postma, & de Haan, 2001; van Honk & Schutter, 2006).

Relatively little is known about the specific neural substrate of anterior EEG asymmetry. The most likely candidate is the dorsolateral prefrontal cortex (dlPFC). Namely, fMRI studies investigating the activation of approach tendencies and reward processing as well as source-localization of anterior EEG asymmetry activity have linked increased left dlPFC activity to approach motivation and relatively left-sided asymmetry (e.g., Berkman & Lieberman, 2010; Pizzagalli, Sherwood, Henriques, & Davidson, 2005) and reduced dlPFC activity to relatively right-sided asymmetry (e.g., Smith, Cavanagh, & Allen, 2018). There is no direct evidence that the right dlPFC is involved in avoidance motivation captured by relatively right-sided anterior EEG alpha asymmetry. However, applying rTMS to the right dlPFC has been shown to reduce anxiety and increase left frontal activity as measured by theta power (Schutter et al., 2001). Described and other studies provide some support for the idea that affect and motivational tendencies may be lateralized in the brain, however, there are also many contradictory findings (e.g., Miller, Crocker, Spielberg, Infantolino, & Heller, 2013). Furthermore, if functional lateralization in affect exists, it is unlikely to extend beyond the dlPFC (e.g., Kringelbach & Rolls, 2004).

Despite the lack of clarity about the neural substrate, there is substantial support for the notion that right-sided and left-sided asymmetry in anterior EEG activity/activation coincide with relatively more avoidance-oriented and relatively more approach-oriented affect, respectively (Coan & Allen, 2004; Harmon-Jones & Gable, 2018; Harmon-Jones et al., 2010; Reznik & Allen, 2018). A large part of this evidence comes from experimental studies manipulating various affective states. For instance, relatively right-sided asymmetry has been elicited by upsetting videos (Papousek et al., 2014), threats of punishment (Sobotka, Davidson, & Senulis, 1992), as well as expression of fear (Coan, Allen, & Harmon-Jones, 2001). Relatively left-sided anterior EEG asymmetry, on the other hand, has been elicited by smiling (Ekman & Davidson, 1993), promises of reward (Sobotka et al., 1992) and, in support of the motivational direction account, insulting feedback that made participants angry (Harmon-Jones & Sigelman, 2001).

Studies focusing on resting state anterior EEG asymmetry as a dispositional measure of "affective style" (Davidson, 1998) have linked relatively right-sided asymmetry with the tendency to experience avoidance-oriented and relatively left-sided asymmetry with the tendency to experience approach-oriented affective states. Namely, right-sided asymmetry in resting state anterior EEG activity has been shown to correlate with such affective individual differences as greater negative affectivity (Tomarken, Davidson, Wheeler, & Doss, 1992), depression, and anxiety (Nusslock, Walden, & Harmon-Jones, 2015; Thibodeau et al., 2006), whereas left-sided asymmetry has been shown to correlate with greater positive affectivity (Tomarken et al., 1992), symptoms of (hypo)mania (Nusslock et al., 2015), and trait anger (Harmon-Jones & Gable, 2018).

Even though associations with resting state anterior EEG asymmetry often align with the affective-motivational model, many studies have also failed to replicate the predicted findings (e.g., Harmon-Jones et al., 2002; Nitschke et al., 1999; Reid et al., 1998; Wacker et al., 2010). As described in Section 1.3., due to unaccounted state effects, it can be difficult to evaluate motivational tendencies using resting state anterior EEG asymmetry. Specifically, even though approximately half of the variance in resting state anterior EEG asymmetry can be attributed to a latent trait, the other half stems from state influences capturing either universal or idiosyncratic responses to the situation (Hagemann, Hewig, Seifert, Naumann, & Bartussek, 2005; Hagemann, Naumann, Thayer, & Bartussek, 2002). Therefore, to clarify the relationship between motivational tendencies and affective individual difference constructs, task-based measures of anterior EEG asymmetry or combinations of task-based and resting state measures should be preferred (Coan et al., 2006)[6]. Task-based measures may yield less generalizable findings but tend to increase the strength and reliability of associations (e.g., Allen & Reznik, 2015; Coan et al., 2006; Meyer et al., 2017; Stewart et al., 2014). Importantly for the CPC framework, given the right context and measurement conditions, anterior EEG asymmetry can therefore be a useful tool for evaluating how motivational tendencies are involved in affective individual difference constructs. The dissertation will next investigate whether standardized affective images are appropriate stimuli for this purpose and will then test the applicability of the CPC framework by investigating the motivational mechanisms of Neuroticism.

[6] It is important to note that, depending on the research question and design, task-based measures can involve either anterior EEG activity (i.e., the level of activity during a task/condition) or activation (i.e., the change from a baseline period).

2.1. Affective images and anterior EEG asymmetry

Despite a large body of evidence suggesting that task-based measures of anterior EEG asymmetry are useful for studying individual differences in approach-avoidance motivation, finding an appropriate experimental design can be challenging. Somewhat surprisingly, it is particularly difficult to investigate differential activation of approach-avoidance tendencies in response to general positive and negative cues. For instance, standardized affective stimuli such as images from the International Affective Picture System (IAPS; Lang et al., 2008) often fail to elicit theoretically predicted shifts in anterior EEG asymmetry (Harmon-Jones & Gable, 2018). These null findings are at odds with positive and negative IAPS images being consistently linked to subjective arousal, prioritized perceptual processing (i.e., motivated attention) as well as modulations of the startle reflex indicative of appetitive and defensive motivation (e.g., Bradley, Codispoti, Cuthbert, & Lang, 2001; Lang & Bradley, 2010, 2013).

It has been suggested that anterior EEG asymmetry captures only relatively strong shifts in approach-avoidance motivation whereby heterogenous image-categories may simply not be activating enough (Harmon-Jones & Gable, 2018). In support of this explanation, high arousal erotic images have been shown to elicit relatively more left-sided anterior EEG asymmetry compared to control images (Schöne, Schomberg, Gruber, & Quirin, 2016) while positive images that range in content and arousal level have not (Elgavish, Halpern, Dikman, & Allen, 2003).

It is also possible that individual differences in motivational responses overshadow the mean level dynamics (Harmon-Jones & Gable, 2018). Such moderating effects have been documented for specific stimuli and specific individual differences. In one study, images of desserts elicited relatively more left-sided anterior EEG asymmetry compared to control images only in people who reported that they liked desserts and/or had not eaten for a long time (Gable & Harmon-Jones, 2008). In another study, anger-inducing images elicited relatively more left-sided anterior EEG asymmetry in people with high trait anger (Harmon-Jones, 2007). So far, stimulus-dependent interindividual variability has not been demonstrated for more general affective categories. However, if either moderately or highly arousing positive and negative IAPS images were to elicit significant interindividual variation in anterior EEG asymmetry responses, then such stimuli could potentially be used to study how the activation of motivational tendencies is implicated in broader affective traits. This possibility was addressed in Study I of the current dissertation[7].

[7] This publication has been included in a previous doctoral dissertation where it was viewed from a different perspective (see Uusberg, 2014).

2.1.1. The experimental design of Studies I and III

Study I as well as Study III reanalyzed the data from an earlier publication (Uusberg, Uibo, Kreegipuu, & Allik, 2013). Current section complements the methods description of Study I and Study III publications, giving a more detailed overview of the experimental design.

The original sample consisted of 85 healthy student volunteers who had normal or corrected to normal vision, were fluent in Estonian, and received research participation credit as a form of compensation. Depending on inclusion criteria like handedness and nonartefactual data percentage the samples of Study I and Study III differ from the original.

The experiment involved viewing five types of affective images with two task instructions (within-participant design). In the **affective evaluation condition** participants were asked to look at the pictures naturally and rate the valence (1 – *extremely unpleasant* to 9 – *extremely pleasant*) and arousal (1 – *not at all arousing* to 9 – *extremely arousing*) of each image. In the **non-affective evaluation condition** participants' attention was directed away from the affective content by asking them to rate the luminance of each image (1 – *extremely dark* to 9 – *extremely bright*) and the numerosity of depicted objects (1 – *one* to 9 – *nine or more*). Two sets of 60 IAPS images were used as stimuli. Each set contained 12 images from five affective categories: **neutral** (e.g., household objects, natural urban scenes, landscapes), **low arousal positive** (e.g., affiliative scenes, sporting activities, appetizing foods), **high arousal positive** (erotic scenes depicting heterosexual couples), **low arousal negative** (e.g., weapons, snakes, scenes of aggression or accidents) and **high arousal negative** (aversive images depicting bodily mutilations)[8]. The sets were balanced for normative ratings, semantic content, and framing. All images from one set were presented in a pseudo-randomized order with one evaluation instruction within one block. Each block was repeated three times before switching to the other evaluation condition. Thus, the experiment entailed 180 trials within each task condition (360 in total) and 36 trials with each affective category and task combination. The order of tasks and task-set pairings were

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[8] IAPS pictures in set A - neutral: 2512, 7004, 7009, 7010, 7030, 7050, 7056, 7150, 7179, 7180, 7217, 7235; low arousal positive: 1590, 2070, 2250, 5629, 5833, 7200, 7340, 7352, 8034, 8185, 8200, 8501; low arousal negative: 1090, 1220, 1274, 1300, 6260, 6313, 6555, 9300, 9480, 9530, 9621, 9901; high arousal positive: 4607, 4611, 4645, 4652, 4659, 4660, 4669, 4670, 4672, 4676, 4687, 4695; high arousal negative: 3010, 3016, 3060, 3064, 3069, 3102, 3150, 3266, 3530, 9250, 9570, 9921. IAPS pictures in set B - neutral: 2190, 7000, 7002, 7020, 7025, 7034, 7040, 7080, 7160, 7175, 7491, 7705; low arousal positive: 1600, 2080, 2260, 5628, 5831, 7330, 7350, 7402, 8030, 8080, 8186, 8502; low arousal negative: 1070, 1205, 1275, 1525, 2120, 6230, 6540, 9301, 9440; 9520; 9620; 9911; high arousal positive: 4599, 4608, 4643, 4651, 4658, 4677, 4680, 4681, 4683, 4690, 4694, 4810; high arousal negative: 2981, 3000, 3015, 3053, 3110, 3120, 3168, 3170, 3400, 9040, 9254, 9410. Note that the labels of the five affective categories differ slightly in Study I (high arousal pleasant, pleasant, neutral, unpleasant, high arousal unpleasant) and Study III (erotic, pleasant, neutral, unpleasant, aversive) publications.

counterbalanced across participants. A single trial started with a fixation cross presented for 1500 ms in the middle of a dark grey screen followed by the stimulus for 1500 ms. Upon stimulus offset two scales appeared consecutively on the screen for participant-controlled time, asking for valence and arousal or luminance and numerosity ratings. Response to the second scale initiated the next trial.

Continuous EEG was recorded with a BioSemi ActiveTwo system from 30 scalp locations, two earlobes, and four linked ocular locations using the CMS/DRL reference scheme,1024 Hz sampling rate, and .16 – 100 Hz band-pass filter. Offline processing was conducted with EEGLAB (Delorme & Makeig, 2004) and Matlab (MathWorks, USA) software. The data were re-referenced to linked ears and downsampled to 256 Hz before performing study-specific preprocessing steps.

As a part of a larger study, resting state EEG was recorded for two minutes before and after the experiment and FFM personality dimensions were assessed with EE.PIP-NEO inventory (Mõttus, Pullmann, & Allik, 2006) after the experiment. The larger study (n = 289) demonstrated that it was not possible to predict personality scores from the power spectra of the resting state EEG data using machine learning algorithms (Korjus et al., 2015; see also Section 1.3.). The resting state data was not separately analyzed in Studies I and III.

2.1.2. Study I – Approach-avoidance activation without anterior asymmetry

From the perspective of the current dissertation, the specific aim of Study I was to investigate whether affective images are appropriate stimuli to study individual differences in the activation of approach-avoidance motivation as measured by anterior EEG asymmetry. Toward that end, Study I first tested whether positive and negative images with varying arousal levels elicited relatively left-sided (i.e., more alpha power over the right hemisphere) and relatively right-sided (i.e., more alpha power over the left hemisphere) asymmetry in anterior EEG activity, respectively. More importantly for the current dissertation, Study I also tested whether images from different affective categories elicited interindividual variability in anterior EEG asymmetry.

The data of 70 right-handed participants from the **affective evaluation condition** of the experiment described in Section 2.1.1. was reanalyzed. The nonaffective evaluation condition was excluded as it was designed to induce top-down cognitive control that can affect motivational responses as well as alpha dynamics (e.g., Klimesch, 2012). It has been shown that specific boundaries of alpha oscillations may vary between people (Klimesch, 1999). To increase the sensitivity of anterior EEG asymmetry, individual alpha frequency (IAF) peak (range 7.5 – 11.5, M = 9.98, SD = .84) was used to define the alpha band (0.8*IAF – 1.3*IAF) instead of the fixed 8–13 Hz range (Doppelmayr, Klimesch, Pachinger, & Ripper, 1998)[9]. Anterior EEG asymmetry scores were calculated for midfrontal (F3/F4) and lateral frontal (F7/F8) sites and were contrasted to self-reported valence and arousal ratings as well as the mean amplitudes of the Late Positive Potential (LPP) component, a widely used correlate of motivated attention (e.g., Hajcak et al., 2011; Schupp, Flaisch, et al., 2006)[10]. To maximize the likelihood of discovering stimulus-dependent interindividual variance in anterior EEG asymmetry activity, Study I used an analysis approach that did not require a priori identification of affective individual difference constructs that would be most relevant for asymmetry in this context. Specifically, mixed model analyses of variance (ANOVAs) were used to decompose the variance in anterior EEG asymmetry as well as other dependent measures into four additive components (cf., Stemmler & Wacker, 2010): the main effect of the affective category, the stimulus-independent interindividual variability (i.e., the main effect of the participant), the stimulus-dependent interindividual variability (i.e., the interaction between the participant and the affective category), and error variance. To conclude the suitability of IAPS images for studying individual differences in the activation of approach-avoidance motivation, the stimulus-dependent interindividual variability component would have to explain a significant amount of overall anterior EEG asymmetry variance.

Study I results showed that IAPS images from the five affective categories elicited expected responses as measured by subjective ratings and the LPP amplitudes. However, replicating several previous reports (Harmon-Jones & Gable, 2018), IAPS images did not modulate anterior EEG asymmetry. More importantly for the current dissertation, the stimulus-dependent interindividual variability component did not explain any of the variance in anterior EEG asymmetry. This suggests that idiosyncratic asymmetry responses to positive and negative images with high and low arousal cannot explain the lack of the affective category main effect. Furthermore, heterogenous sets of affective images are probably not suitable to probe individual differences in approach-avoidance motivation with anterior EEG asymmetry.

Anterior EEG asymmetry recorded in response to IAPS images was significantly determined only by the stimulus-independent interindividual variability that could originate from stable trait-like asymmetry patterns (Hagemann et al., 2005, 2002) as well as unaccounted state dynamics elicited by the general measurement context (e.g., Blackhart et al., 2002). The extent of stimulus-independent interindividual variability in the task-based anterior EEG asymmetry suggests that in order to detect context-dependent activation of motivational tendencies the asymmetry responses of interest should be baseline-

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[9] Note, however, that the data averaged for the fixed 8-13 Hz frequency band yielded comparable results, suggesting that IAF based frequency band did not have a notable effect on the sensitivity of anterior EEG asymmetry to individual differences.

[10] LPP and other ERP components that are used to assess motivated attention are described in greater detail in Section 3.

corrected (i.e., focus on anterior EEG asymmetry activation) and contrasted to well-matched control conditions.

The question remains, why affective images did not elicit theoretically predicted shifts in anterior EEG asymmetry if they were processed in a prioritized manner and were subjectively perceived as affect inducing. The fact that Study I included homogeneous high arousal aversive as well as erotic image-categories that elicited expected LPP responses (cf., Schupp, Cuthbert, et al., 2004; Weinberg & Hajcak, 2010) largely rules out the possibility that the stimuli were not affectively salient enough. It is possible, however, that they lacked sufficient personal relevance. Thus, the most likely explanation for the asymmetry null finding is that even though passive viewing of IAPS images commanded motivated attention it did not elicit action tendencies or general action readiness.

There are several reports of action readiness manipulations significantly modulating changes in anterior EEG asymmetry. For instance, reclining body-posture has been shown to eliminate the left-sided anterior EEG asymmetry responses to approach-related stimuli documented for upright or forward-leaning body-posture (e.g., Harmon-Jones, Gable, & Price, 2011; Harmon-Jones & Peterson, 2009). Similarly, the possibility to actively respond to anger-provoking information after the study (i.e., sign a petition against tuition increase) has been shown to amplify the left-sided asymmetry in anterior EEG activity (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). A recent source-localization study also linked left-sided anterior EEG asymmetry to brain regions involved in preparation for and instantiation of approach-motivated action tendencies (Smith et al., 2018). These and Study I findings suggest that perceived or actual ability to act on motivational tendencies may play a crucial role in eliciting state dependent asymmetry in anterior EEG activity/activation. Therefore, to use task-based measures of anterior EEG asymmetry for studying the motivational mechanisms of affective individual difference constructs, the experimental manipulation should entail highly salient stimuli as well as elicit action tendencies or action readiness. These principles were put to the test in Study II of the current dissertation.

2.2. Clarifying the relationship between Neuroticism and approach-avoidance motivation

One research area that might benefit from incorporating anterior EEG asymmetry is the motivational mechanisms of Neuroticism. Neuroticism has been frequently associated with avoidance tendencies and temperament (e.g., Elliot & Thrash, 2002, 2010; McNaughton, DeYoung, & Corr, 2016). However, studies have not found a consistent relationship between Neuroticism and relatively right-sided anterior EEG asymmetry (e.g., Minnix & Kline, 2004; Schmidtke & Heller, 2004). Given the notable body of evidence for the relationship between right-sided anterior EEG asymmetry and more specific affective individual difference constructs that are associated with Neuroticism, such as anxiety and depression (e.g., Harmon-Jones & Gable, 2018; Reznik & Allen, 2018), the lack of direct empirical links is somewhat puzzling. It is possible that the null findings simply stem from methodological factors. Because Neuroticism is a broad trait that effects behavior and affect across situations, researchers might be particularly interested in resting state anterior EEG asymmetry, hoping to tap into general Neuroticism-related motivational tendencies. However, as discussed in Section 1.3., resting state recordings can be vulnerable to unaccounted state effects that might distort or hide the underlying patterns (e.g., Blackhart et al., 2002; Coan et al., 2006; Stemmler & Wacker, 2010; Wacker et al., 2013).

Alternatively, Neuroticism may be a motivationally heterogeneous construct rendering the domain level ill-suited to investigate relationships with approach-avoidance tendencies. Specifically, it has been proposed that Neuroticism can be decomposed into two aspect factors that differ, among other things, in their motivational underpinnings (DeYoung et al., 2007). The Withdrawal aspect entails such internalizing facets as Anxiety, Self-consciousness, Depression, and Vulnerability that should be linked to greater avoidance motivation and relatively right-sided anterior EEG asymmetry (e.g., Thibodeau et al., 2006). The Volatility aspect, however, entails such externalizing facets as Angry-hostility and Impulsiveness that should be related to greater approach motivation and relatively left-sided anterior EEG asymmetry (e.g., Harmon-Jones & Gable, 2018). When focusing on the Neuroticism domain level, the tendencies associated with aspect factors may therefore mask each other's effects.

To clarify the relationship between Neuroticism and avoidance motivation as indexed by relatively right-sided anterior EEG asymmetry, it would be important to test whether the hypothesized relationship is revealed in a trait-relevant experimental setting as well as whether the relationship is specific to the Withdrawal aspect of the broader domain. The task-based approach inevitably moves the focus from general motivational tendencies to specific mechanisms, presenting an opportunity to test the applicability of the CPC framework.

According to the CPC framework, specific psychological mechanisms of Neuroticism (i.e., the affective individual difference construct of interest) are best detectable at the intersection of Neuroticism-relevant contextual demands and processing biases. The Neuroticism-relevant affective process of interest is in this case the activation of approach-avoidance motivation, as measured by changes in anterior EEG asymmetry, and the hypothesized bias in the process is greater avoidance tendency in people with higher Neuroticism, as indexed by relatively right-sided anterior EEG asymmetry response. The question remains, however, what would be a Neuroticism-relevant context and a methodologically suitable experimental design that would help to reveal informative differences in approach-avoidance motivation.

The broad nature of Neuroticism poses some challenges for selecting the context and the design as they should ideally be rather universal and capture dynamics that are central to Neuroticism. Given that at the core of Neuroticism is negative emotionality (e.g., Allik & Realo, 1997; Markon et al., 2005; Watson & Clark, 1992), it would have been appealing to use affective scenes ranging in valence and arousal (e.g., IAPS images; Lang et al., 2008) to see whether higher Neuroticism is associated with stronger avoidance motivation in response to general negative cues. However, as Study I demonstrated, affective images may not be well-suited for investigating individual differences in anterior EEG asymmetry. Instead, more specific motivational mechanisms should be targeted with this measure, using stimuli with greater self-relevance that elicit action tendencies or action readiness.

Social interaction is one context with the potential to illuminate meaningful motivational mechanisms of Neuroticism. There is evidence that complex social manipulations (i.e., giving public vs. private negative feedback) can reveal relationships between anterior EEG asymmetry and affective individual difference constructs considered to be facets of Neuroticism (i.e., anxiety and defensiveness; Crost et al., 2008). However, to get at the more basic motivational mechanisms of Neuroticism, the complexity of social interactions should be decomposed into simple and well-controllable factors that pose distinct demands and could be presented as discrete stimuli.

One of the most basic features of social interaction is the degree of social contact as indicated by the gaze of the partner (e.g., Cook, 1977). Gaze direction signals the locus of attention as well as the motivational tendencies of another person (e.g., Adams & Kleck, 2005; Emery, 2000) and is in general a very salient and informative social signal. Direct gaze, however, is a particularly powerful signal because it indicates that one is the target of someone's attention and should attempt to understand the nature and relevance of their intentions. Relatedly, direct gaze has been shown to induce "mentalizing" (e.g., Wicker, Perrett, Baron-Cohen, & Decety, 2003) and self-referential processing (Conty, George, & Hietanen, 2016; Hietanen & Hietanen, 2017) as well as speed up the detection of approach-related facial expressions such as anger and joy (e.g., Adams & Kleck, 2005).

Engaging in mutual gaze or eye contact as well as tracking another person's gaze can also be considered a simple form of behavior that is fairly automatic and develops already in infancy (e.g., Frischen, Bayliss, & Tipper, 2007; Nummenmaa & Calder, 2009). Following someone's gaze should therefore have the potential to elicit approach and avoidance action tendencies, and therefore anterior EEG asymmetry. Indeed, seeing the direct gaze of a social partner, signaling interest and approach motivation, has been shown to induce relatively left-sided anterior EEG asymmetry and seeing the averted gaze of a social partner, signaling lack of interest and avoidance motivation, has been shown to induce relatively right-sided anterior EEG asymmetry (e.g., Hietanen, Leppänen, Peltola, Linna-aho, & Ruuhiala, 2008; Pönkänen, Peltola, & Hietanen, 2011). There is evidence, however, that this kind of reciprocity of motivational tendencies during social interaction is not universal but may instead depend on affective individual differences, including Neuroticism. Specifically, people with high Neuroticism have been shown to rate direct gaze as subjectively less approachable (Helminen, Kaasinen, & Hietanen, 2011). They may also be more likely to exhibit behavioral gaze avoidance (e.g., Campbell & Rushton, 1978). These findings raise the interesting possibility that the activation of avoidance motivation during social interaction, particularly in response to direct gaze or eye contact, may be mechanistically involved in Neuroticism.

The CPC framework emphasizes the role of contextual demands in specific psychological mechanism that alter the relevance of certain contextual features depending on where people fall on the affective individual difference spectrum of interest. What would be the demand that direct gaze poses on people with high Neuroticism that could lead to different motivational responses compared to people with low Neuroticism? It is possible that due to greater self-consciousness people with high Neuroticism exhibit stronger increase in self-awareness while being the target of someone's attention (cf., Baltazar et al., 2014; Conty et al., 2016). Due to greater anxiety they may also interpret the situation as more threatening (e.g., Ormel, Bastiaansen, et al., 2013). Given the nature of these hypothesized demands, the avoidance response to another person's attention should be primarily related to the Withdrawal aspect of Neuroticism.

Another important clarification from the CPC perspective is that the activation of avoidance motivation during neutral social interaction could hypothetically be implicated in the phenotypical expression of Neuroticism/ Withdrawal, thereby fitting the definition of a psychological mechanism used in the current dissertation. For instance, the experience of avoidance tendencies in response to neutral attention could, among other things, foster negative and hinder positive interpretations of the interaction that in turn could feed into increased negative and reduced positive emotionality.

2.2.1. Study II – Eye contact reveals a relationship between Neuroticism and anterior EEG asymmetry

As outlined in Section 2.2., the activation of avoidance tendencies in response to social contact may constitute a psychological mechanism of Neuroticism. This possibility was tested in Study II by measuring changes in anterior EEG asymmetry in response to the gaze direction of another person. It was hypothesized that someone's directed attention, as signaled by direct gaze, elicits relatively more right-sided anterior EEG asymmetry (i.e., more alpha power over the left frontal regions) in people with higher Neuroticism. Study II also tested whether the activation of avoidance motivation in response to directed attention is specific to the Withdrawal aspect of the broader domain.

Continuous EEG was recorded while 40 adult volunteers, endorsing variable levels of Neuroticism as measured by the Finnish version of the "Short Five" personality questionnaire (Konstabel, Lönnqvist, Walkowitz, Konstabel, & Verkasalo, 2012), faced a female model through a liquid crystal shutter-window with changeable transparency. Two women served as models and their identity was counterbalanced across participants based on participants' gender and personality scores. The degree of social contact was manipulated within-participant by varying the gaze direction of the model. The model bore a neutral facial expression and, in different conditions, either looked directly at the participant (**the direct gaze condition**, designed to elicit eye contact), looked away (**the averted gaze condition**) or had her eyes closed (**the closed eyes condition**). Each condition entailed nine trials with five seconds of social contact (i.e., shutter open) presented in a pseudo-randomized order. The participant was instructed to simply look at the window and, when the model appeared, look at her naturally. To isolate the effect of social contact on anterior EEG asymmetry, event-related changes were calculated for each gaze condition in relation to the shutter opening (i.e., asymmetry activation). Specifically, the alpha power values were obtained by averaging the event-related spectral perturbations within the 8–13 Hz band[11]. The anterior EEG asymmetry results from the midfrontal electrode pair (F4/F3) were corroborated with behavioral and subjective measures collected in separate parts of the experiment. First, the behavioral direct gaze avoidance was evaluated by comparing voluntary looking times of direct and averted gaze when the participants were instructed to open and close the shutter-window whenever it felt natural. Second, subjective direct gaze avoidance was assessed by collecting retrospective ratings for the valence and arousal of the viewing experience as well as the pleasantness, dominance, and approachability of the model in all three gaze conditions. Additionally, resting state EEG was recorded before and after the experiment to confirm that changes in anterior EEG asymmetry in response to gaze manipulations were more strongly related to Neuroticism than the resting state asymmetry. The analyses focused on the Neuroticism domain, however, for significant interactions the effects of the two aspect factors were decomposed.

As predicted, direct gaze elicited a more right-sided anterior EEG asymmetry response in participants with higher Neuroticism, suggesting a relatively greater increase in avoidance motivation (or decrease in approach motivation). Importantly, Neuroticism was not related to the resting state anterior EEG asymmetry or anterior EEG asymmetry activation in responses to averted gaze and closed eyes. The specificity of asymmetry results supports the hypothesized motivational mechanism of Neuroticism whereby in the context of social interaction people with higher Neuroticism experience avoidance tendencies in response to another person's directed attention (see also Figure 2). This

[11] Given that in Study I the individual alpha frequency band did not increase the sensitivity of anterior EEG asymmetry to individual differences, the more traditional fixed 8-13 Hz frequency band was used in Study II.

interpretation was supported by their greater behavioral direct gaze avoidance. Namely, the universal tendency to voluntarily look at the averted gaze longer than the direct gaze was amplified for people with higher Neuroticism.

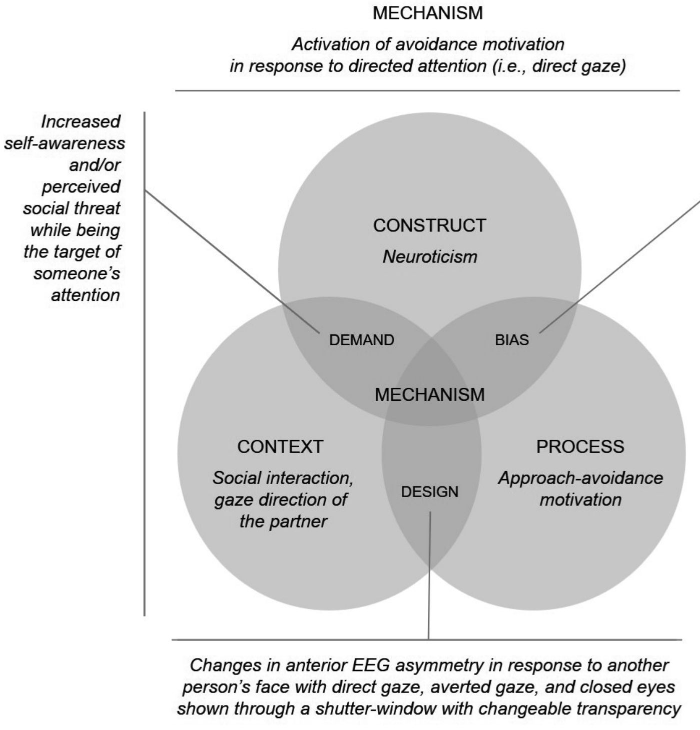

Figure 2. Summary of Study II according to the CPC framework. The activation of avoidance tendencies in response directed attention during social interaction, possibly due to increased self-awareness and/or perceived social threat, may constitute a psychological mechanism on Neuroticism.

Unfortunately, the experimental design of Study II did not allow to confirm that the Neuroticism-related demand posed by direct gaze was increased self-awareness and/or perceived social threat. Nevertheless, people with higher Neuroticism tended to give more positive valence ratings for the averted gaze, suggesting that they may have felt relatively more comfortable during that condition. The avoidance response to directed attention in people with higher Neuroticism may also be linked to their broader intolerance of uncertainty. Specifically, considering that the model bore a neutral expression, a direct gaze might have constituted a salient but ambiguous social cue. Previous studies have shown, however, that people with high Neuroticism tend to avoid affectively ambiguous stimuli in general or react to them more strongly (e.g., Hirsh & Inzlicht, 2008; Lommen, Engelhard, & van den Hout, 2010).

As predicted, the right-sided anterior EEG asymmetry response to direct gaze was primarily related to the unique variance associated with the Withdrawal aspect (DeYoung et al., 2007) of the broader Neuroticism domain. Similar Withdrawal specificity emerged for the more positive averted gaze valence ratings. These aspect factor findings provide preliminary evidence that the avoidant reaction to another person's attention stems primarily from the internalizing facets of Neuroticism i.e., Anxiety, Depression, Self-consciousness, and Vulnerability. They also support the notion that the Withdrawal and Volatility aspect factors differ with regards to underlying motivational tendencies (e.g. Corr et al., 2013; Cunningham, Arbuckle, Jahn, Mowrer, & Abduljalil, 2010). In the current study the motivational tendencies of Withdrawal and Volatility likely did not counteract each other and therefore the relationship between Neuroticism and anterior EEG asymmetry was revealed also on the domain level. However, it is possible that other contexts, such as confrontational social interactions (cf., Crost et al., 2008), might pose different if not opposing demands, depending on the level of Withdrawal and Volatility.

In conclusion, Study II demonstrated that the principles of the CPC framework can be successfully used to conceptualize the motivational mechanisms of broad affective traits and design experiments for revealing them. The findings suggest that the tendency to experience avoidance motivation in response to another person's directed attention is a potential psychological mechanism of Neuroticism (see also Figure 2). Despite being rather specific, this mechanism could contribute meaningfully to the phenotypical expressions the trait, mainly negative affectivity. It remains to be tested in future studies, but avoidance responses to neutral social contact could also lower the quality of social relationships of people with high Neuroticism (e.g., Ozer & Benet-Martínez, 2006). For instance, the experience of avoidance motivation might increase the likelihood of negative interpretations and thereby directly reduce the perceived quality of the interaction (or the entire relationship). Avoidance tendencies might also lead to avoidant behavior such as gaze avoidance, that has been shown to elicit less favorable judgements from others (e.g., Droney & Brooks, 1993; Larsen & Shackelford, 1996). Less favorable impressions could in turn reduce the prosocial behavior of the interaction partner. Avoidant responses to social contact could also be implicated in Neuroticism-related risk for the development of social anxiety disorder that has been associated with very similar anterior EEG asymmetry responses to direct gaze (e.g., Myllyneva, Ranta, & Hietanen, 2015).

2.3. Interim summary

Anterior EEG asymmetry has been used to analyze the approach-avoidance motivation accompanying acute affective responses (i.e., the task-based approach) as well dispositional tendencies to experience approach-oriented and avoidance-oriented affective states (i.e., the resting state approach; e.g., Harmon-Jones & Gable, 2018; Reznik & Allen, 2018). When investigating the motivational mechanism of affective individual difference constructs, task-based measures of anterior EEG asymmetry tend to provide less generalizable but more reliable as well as better informed insights and should therefore be preferred over resting state measures (e.g., Allen & Reznik, 2015; Coan et al., 2006; Meyer et al., 2017; Stewart et al., 2014). The specificity that is required from task-based measures of anterior EEG asymmetry poses, however, some difficulties for studying the motivational mechanism of multifaceted affective traits. For instance, as demonstrated in Study I, heterogeneous sets of affective images, that are widely used to answer other questions about affective processes (e.g., Lang & Bradley, 2010), may not be well-suited to elicit changes in anterior EEG asymmetry. Therefore, more specific motivational mechanisms of broad affective traits should be targeted than differences in reactivity to general negative and positive cues.

As demonstrated in Study II, following the principles summarized in the CPC framework can help reveal potential motivational mechanisms of broad affective traits, in this case Neuroticism. The findings of Study II suggest that Neuroticism is related to the activation of avoidance tendencies in response to another person's directed attention. They also indicate that the activation of avoidance response during this kind of neutral social interaction stems primarily from the Withdrawal aspect of the broader domain. This specificity supports the notion that the two aspect factors of Neuroticism – Withdrawal and Volatility – have different motivational underpinnings (e.g. Corr et al., 2013; Cunningham et al., 2010; DeYoung, 2010) and may therefore be a more appropriate level of analysis for clarifying the relationships between anterior EEG asymmetry and personality. Study II also illustrates more generally how social interaction can be a powerful context for studying the motivational mechanisms of affective individual difference constructs with anterior EEG asymmetry.

3. MOTIVATED ATTENTION AND EVENT-RELATED POTENTIAL COMPONENTS

Motivated attention refers to a phenomenon whereby affectively salient information has the capacity to command selective attention and enhance cognitive processing (e.g., Lang et al., 1997; Vuilleumier, 2015). Heightened attention toward affective information can be viewed as an extension of a reflexive orienting response toward novel stimuli (Pavlov, 1927) that habituates rapidly if the stimulus is motivationally irrelevant (e.g., Sokolov, 1963). However, motivated attention goes beyond the orienting response as it involves a broader and more sustained bias in the allocation of cognitive resources to process affectively salient information (e.g., Lang & Bradley, 2010; Pourtois et al., 2013; Vuilleumier, 2005).

Motivated attention can be assessed with task-based measures that allow to evaluate attentional biases and/or variations in sensory processing, including behavioral paradigms, eye-tracking, and neuroimaging (e.g., Pourtois et al., 2013). For instance, affective stimuli speed up target detection in dot-probe tasks (e.g., Brosch, Pourtois, Sander, & Vuilleumier, 2011) and are themselves detected faster in visual search tasks (e.g., Eastwood, Smilek, & Merikle, 2001; Ohman, Flykt, & Esteves, 2001). They increase the Stroop effect (e.g., Richards & Blanchette, 2004; Williams, Mathews, & MacLeod, 1996) and tend to be fixated on in a prioritized manner (e.g., Nummenmaa, Hyönä, & Calvo, 2006). Affective stimuli can also elicit greater activation in different sensory areas, including primary visual cortex, category selective temporal regions, as well as posterior occipital and parietal regions (Lang & Bradley, 2010; Pourtois et al., 2013; Vuilleumier, 2005, 2015).

The studies featured in the current dissertation infer differences in motivated attention from modulations of ERP components. ERPs are averaged time-locked voltage fluctuations in the EEG signal recorded in response to distinct events. They are thought to reflect changes in the electrical brain activity produced by summated post-synaptic potentials of cortical pyramidal neurons (Fabiani, Gratton, & Federmeier, 2007; Luck, 2005). ERP components, in turn, are temporally and spatially distinguishable positive and negative deflections in ERP waveforms that correspond to relatively specific mental processes (Fabiani et al., 2007; Luck, 2004). Relatedly, modulations of ERP components correspond to changes in the processing resources allocated to perform a given mental operation. Depending on the task and the type of stimuli, affective salience can modulate a wide range of ERP components (Hajcak et al., 2011; Olofsson et al., 2008; Pourtois et al., 2013; Schupp, Flaisch, et al., 2006)[12]. This concurs with the notion that motivated attention impacts stimulus processing during various stages.

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[12] The studies featured in the current dissertation use visual stimuli, therefore, only affective modulations to visual ERP components are discussed.

Several early ERP components that correspond to domain-general visual processing exhibit sensitivity to affect. For instance, both the occipital P1 (peaks typically between 100 and 130 ms) and the anterior N1 (peaks typically between 100 and 150 ms), that reflect early sensory processing in the extra-striate visual cortex (Luck, 2005; Olofsson et al., 2008), can be amplified in response to negatively or positively valenced stimuli (Hajcak et al., 2011; Olofsson et al., 2008; Pourtois et al., 2013). Similarly, the fronto-centrally maximal P2 (onsets typically between 180 and 200 ms), that is related to selective attention (Carretié, Hinojosa, Martín-Loeches, Mercado, & Tapia, 2004; Carretié, Mercado, Tapia, & Hinojosa, 2001; Luck & Hillyard, 1994), has been shown to be larger in response to affective scenes (Carretié et al., 2004, 2001; Delplanque, Lavoie, Hot, Silvert, & Sequeira, 2004), facial expressions of emotion (Eimer, Holmes, & McGlone, 2003), as well as words with emotional connotation (Kanske & Kotz, 2007).

Domain-specific early visual ERP components have also shown sensitivity to affective salience. Most notably, the N170 (peaks typically between 140 and 200 ms over occipito-temporal regions), that reflects structural encoding of faces (Eimer, 2000; Itier & Taylor, 2004a) in the fusiform face area (e.g., Itier & Taylor, 2004b; Sadeh, Podlipsky, Zhdanov, & Yovel, 2010), has been frequently shown to be larger in response to faces with emotional compared to neutral expression (Hinojosa, Mercado, & Carretié, 2015). The body-sensitive equivalent of N170, often referred to as the N190 (peaks over temporal regions, latency depends on the presence of face/head; de Gelder et al., 2010; Thierry et al., 2006), that reflects encoding of bodies in the extrastriate body area (Taylor, Wiggett, & Downing, 2009; Thierry et al., 2006), can also be amplified by cues of motivational significance, namely emotional body postures (e.g., Borhani, Borgomaneri, Làdavas, & Bertini, 2016; Borhani, Làdavas, Maier, Avenanti, & Bertini, 2015) and nudity (Alho, Salminen, Sams, Hietanen, & Nummenmaa, 2015; Hietanen, Kirjavainen, & Nummenmaa, 2014; Hietanen & Nummenmaa, 2011)[13].

The Early Posterior Negativity (EPN) is a slightly later correlate of motivational significance that is thought to index perceptual encoding and has been linked to the transition from early large-capacity to subsequent capacity-limited processing (Schupp, Flaisch, et al., 2006). EPN is evident as a negative deflection in the occipital-temporal ERP (develops typically around 150 ms and is maximal from 250 to 300 ms) in response to emotionally arousing compared to neutral stimuli (Junghöfer, Bradley, Elbert, & Lang, 2001; Schupp, Junghöfer, Weike, & Hamm, 2004; Schupp, Markus, Weike, & Hamm, 2003). Unlike the above-described early ERP components that can exhibit sensitivity to affect but are mainly associated with general cognitive operations, the EPN

[13] It is possible that affective modulations of N170 and N190 amplitudes stem from overlapping activity from different generators whereby the encoding of faces or bodies and affective meaning are parallel but independent processes (Rellecke, Sommer, & Schacht, 2012b).

has been predominantly associated with selective processing of affective information (Hajcak et al., 2011; Schupp, Flaisch, et al., 2006). However, the EPN can also be amplified in response to other stimulus features such as depictions of people compared to depictions of objects (Schupp, Flaisch, et al., 2006) and simple compared to complex figure-ground compositions (Bradley, Steven, Andreas, & Lang, 2007).

Motivational significance modulates also later ERP components, mainly P3 and the Late Positive Potential (LPP). P3 refers to a positive deflection in the midline ERP that is elicited by task-relevant or salient stimuli (peaks typically between 250 and 500 ms; e.g., Hajcak et al., 2011; Olofsson et al., 2008; Picton, 1992; Polich, 2007). Two P3 subcomponents have been distinguished: a frontal P3a (referred to also as frontal P3) and a parietal P3b (referred to also as simply P3 or P300; Polich, 2007). P3a is thought to index stimulus-driven attention allocation and has been related to deviance detection and reorienting. P3b, on the other hand, is thought to index more task-dependent attention allocation (e.g., target detection) and has been related to context updating as well as initial memory consolidation (Delplanque et al., 2004; Polich, 2007). A large body of research has demonstrated that compared to neutral stimuli both positive and negative stimuli elicit a centro-parietally maximal P3-like shift in ERP. This "affective" P3 has been recorded in response to words (e.g., Kissler, Herbert, Winkler, & Junghofer, 2009; Naumann, Bartussek, Diedrich, & Laufer, 1992), facial expressions (e.g., Cacioppo, Stephen, Berntson, & Coles, 1993; Schupp, Ohman, et al., 2004), as well as complex scenes (e.g., Ferrari, Bradley, Codispoti, & Lang, 2009; Mini, Palomba, Angrilli, & Bravi, 1996; Schupp et al., 2000). The fact that various affective cues elicit a response resembling the P3b subcomponent suggests that they are processed as "natural targets" due to inherent motivational salience (Hajcak, MacNamara, & Olvet, 2010; Hajcak et al., 2011; Olofsson et al., 2008). The link between P3 and motivated attention is further supported by studies associating P3 with activity in the ascending locus coeruleus norepinepherine (LC-NE) system (Nieuwenhuis, Aston-Jones, & Cohen, 2005) that receives inputs from the amygdala and is involved in orienting toward motivationally significant cues (Liddell et al., 2005; Nieuwenhuis et al., 2005).

LPP is a sustained positive deflection in midline centro-parietal ERP (Hajcak et al., 2010, 2011; Lang & Bradley, 2010; Schupp, Flaisch, et al., 2006) that is most prominent between 400 and 600 ms but can become evident already by 300 ms and can last for several seconds (Hajcak et al., 2011; Schupp, Flaisch, et al., 2006). In fact, LPP is an aggregated waveform that encompasses multiple overlapping positivities (e.g., Foti, Hajcak, & Dien, 2009). The earlier portion of LPP coincides with P3b and captures primarily selective attention to task-relevant or inherently salient stimuli. The later portions, sometimes referred to as the Slow Wave (SW), reflect sustained attentive processing as well as cognitive elaborations (Hajcak et al., 2010; Olofsson et al., 2008; Schupp, Flaisch, et al., 2006)[14]. There is a large body of evidence linking LPP to preferential processing of motivationally significant stimuli. LPP has been consistently found to be larger in response to both pleasant and unpleasant compared to neutral stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp, Ohman, et al., 2004; Schupp et al., 2000; Schupp, Junghöfer, et al., 2004). Furthermore, the amplification of LPP amplitude has been found to correlate with subjective (Cuthbert et al., 2000; Schupp, Cuthbert, et al., 2004; Weinberg & Hajcak, 2010) as well as autonomic arousal (Cuthbert et al., 2000). LPP has also been shown to distinguish stimulus categories based on evolutionary significance, being largest in response to stimuli depicting threat and sexual cues but differentiating also neutral scenes with and without people (e.g., Schupp, Cuthbert, et al., 2004; Weinberg & Hajcak, 2010). It has been suggested that LPP corresponds to elaborated perceptual processing in the extrastriate visual cortex (Lang & Bradley, 2010). Increased activity in visual cortex in response to emotional stimuli has in turn been linked to direct and indirect projections from amygdala that facilitate perceptual enhancement of salient stimuli (e.g., Pourtois et al., 2013; Vuilleumier, 2005, 2015). It is therefore possible that LPP is a proxy for downstream processes resulting from increased amygdala activation (e.g., Hajcak et al., 2010).

Taken together, the body of empirical evidence suggests that affective salience influences stimulus processing across various consecutive stages. Established associations between discrete affect-sensitive ERP components and specific cognitive processes as well as the high temporal resolution of EEG make the ERP-methodology a useful tool for disentangling the dynamics of motivated attention. Tracing modulations to ERP components can therefore be useful also for investigating the attentional mechanisms of affective individual difference constructs.

3.1. The automaticity of motivated attention

Preferential processing of affective information can be automatic but can also be modulated by top-down factors (Hajcak et al., 2010; Pessoa, 2005; Pourtois et al., 2013; Schupp, Flaisch, et al., 2006; Vuilleumier, 2005). This suggest that when clarifying how variations in motivated attention contribute to affective individual differences, it is also important to clarify how automatic these contributions are. For instance, high anxiety has been linked to enhanced detection but also later avoidance of threat cues. The former dynamic is presumed to be rather automatic the latter, however, more controlled or strategic (e.g., Cisler & Koster, 2010). In the CPC framework the automaticity of motivated attention should be viewed as a characteristic of the psychological

[14] Sometimes LPP is used to denote only the earlier segment of the centro-parietal positivity that overlaps with P3 and SW is used to denote the later segments (e.g., Olofsson, Nordin, Sequeira, & Polich, 2008; Schupp, Flaisch, Stockburger, & Junghöfer, 2006)

process of interest. Addressing the automaticity question can also have practical implications. For instance, knowing whether the prioritization of certain information is automatic or not can inform potential ways to modify that bias.

Definitions of automaticity often emphasize four features – unintentionality, uncontrollability, efficiency, and unconsciousness (e.g., Bargh, 1994). According to these accounts, automaticity refers to the extent to which a process unfolds without intent, control, effort, and/or awareness. Unintentional processes operate without a goal to engage in them. Uncontrollable processes cannot be stopped, altered, or prevented. Efficiency or effortlessness refers to independence of capacity-limited cognitive resources. Unconsciousness can refer to lack of awareness about the cause of the process, the effect of the process, or the cause-effect relationship (e.g., Bargh, 1994; Moors, 2016; Moors & De Houwer, 2006). Some dual-process theories use these and similar features to define two distinct classes of psychological processes, one automatic and the other controlled. However, it has become increasingly evident that automaticity is not a unitary phenomenon but different automaticity features are gradual and may or may not coincide with one another (e.g., Melnikoff & Bargh, 2018; Moors & De Houwer, 2006). Therefore, it may be best to describe automaticity in relative terms (i.e., more or less automatic) and, whenever possible, the contribution from different automaticity features should be specified.

Earlier ERP components are generally considered to index more automatic processes than later ERP components, given the observation that more automatic processes tend to be faster than less automatic processes (e.g., Moors, 2016; Moors & De Houwer, 2006). In line with that notion, rather consistent evidence suggests that LPP is a maker of relatively nonautomatic prioritization of affective information. Affective LPP amplifications require conscious recognition of stimuli (e.g., Williams et al., 2007), are sensitive to cognitive load manipulations (e.g., MacNamara, Ferri, & Hajcak, 2011), are amplified by intentional processing of affect (e.g., Rellecke, Sommer, & Schacht, 2012a; Schupp, Stockburger, Codispoti, et al., 2007), and can be deliberately down-regulated (e.g., Hajcak & Nieuwenhuis, 2006; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). However, the correspondence between earlier ERP correlates of motivated attention and automaticity features is less clear. For instance, EPN seems to index unintentional (e.g., Rellecke et al., 2012a; Schupp, Stockburger, Codispoti, et al., 2007) but not necessarily effortless (e.g., Schupp, Stockburger, Bublatzky, et al., 2007) prioritization of affective stimuli. Furthermore, the timing and nature of the transition from more to less automatic prioritization of affective information also needs clarification. Study III of the current dissertation addressed the transition-related questions by focusing on intentionality effects.

3.1.1. Study III – Unintentionality of affective attention across visual processing stages

The specific aim of Study III[15] was to clarify the automaticity of motivated attention across early and late visual processing stages by investigating the dependence of ERP modulations on the intention to process the affective meaning of stimuli. Toward that end the ERP data of 79 participants from the experiment described in Section 2.1.1. (Uusberg et al., 2013) was reanalyzed. The five affective stimulus categories distributed across three levels of arousal (i.e., neutral, low arousal pleasant and unpleasant, high arousal pleasant and unpleasant) were expected to attract gradually increasing levels of motivated attention. At the same time, the affective evaluation condition and the non-affective evaluation condition mapped onto intentional and unintentional processing of affective information, respectively. Several previous studies investigating the effects of intentionality on motivated attention (e.g., Schupp, Stockburger, Codispoti, et al., 2007; Weinberg, Hilgard, Bartholow, & Hajcak, 2012) have relied on binary decisions (e.g., is the image aversive or not vs. does the image contain people or not) that are characterized by rapid distinctions (e.g., Bargh, 1994). To assess the unfolding of intentional affect processing through relatively late cognitive elaboration stages, polytomous subjective affect ratings (i.e., the valence and arousal) were contrasted to matched nonaffective ratings (i.e., the perceived luminance of the image and the number of depicted objects).

The main hypothesis of Study III was that the effect of intention increases gradually from earlier to later processing stages (e.g., Schupp, Flaisch, et al., 2006). Therefore, the prioritized encoding of affectively salient stimuli, captured by the occipital EPN, was expected to be predominantly unintentional whereas the subsequent sustained attentive processing, captured by the centro-parietal LPP, was expected to be modulated by intention (e.g., Ferrari, Codispoti, Cardinale, & Bradley, 2008; Rellecke et al., 2012a; Schupp, Stock-burger, Codispoti, et al., 2007). For LPP the earlier P3-like and the later Slow Wave (SW) subcomponent (e.g., Foti et al., 2009; Weinberg et al., 2012) were distinguished to clarify when and how the stimulus-driven and deliberate allocation of attention become integrated.

It has been demonstrated that in sets of affective images the physical characteristics of stimuli tend to covary with valence and arousal (e.g., Delplanque, N'diaye, Scherer, & Grandjean, 2007) and, more importantly, that some physical characteristics can impact ERP modulations (e.g., Carretié, Hinojosa, López-Martín, & Tapia, 2007; De Cesarei, Mastria, & Codispoti, 2013). In Study III the mean amplitudes of all ERP components of interest covaried to some extent with stimulus luminance as well as spatial frequency. To avoid confounding the effects of affective content and intention with the

[15] This article has been included in a previous doctoral dissertation where it was discussed in greater detail (see Uusberg, 2014).

effects of basic perceptual features, the contribution of the latter were statistically removed before testing the main hypotheses[16].

The findings of manipulation check analyses on data averaged across the two intentionality conditions converged with previous reports. Compared to the neutral baseline category, the EPN was amplified mainly by high arousal positive but also by high and low arousal negative images (cf., Junghöfer et al., 2001; Schupp, Junghöfer, et al., 2004). The P3 portion of the LPP was amplified by high arousal positive, and high arousal negative images while the SW portion of the LPP was amplified by all four affective categories (cf., Schupp, Cuthbert, et al., 2004; Weinberg & Hajcak, 2010). Furthermore, the self-reported valence and arousal ratings of the affective evaluation condition corresponded mostly with the normative ratings (Lang et al., 2008).

As predicted, the effects of intentionality gradually increased over consecutive processing stages. The evaluation condition did not have an effect on EPN amplitudes, suggesting that early motivated attention can be considered unintentional (e.g., Rellecke et al., 2012a). During the P3-window, there was a significant affect main effect and a significant intentionality main effect but no interaction (e.g., Ferrari et al., 2008). Namely, in all five image-categories the P3 amplitudes were larger during the affective evaluation compared to the nonaffective evaluation condition, suggesting that the intention to process affective meaning increased attention allocation to stimuli indiscriminately. During the SW, an interaction emerged whereby intentional processing continued to amplify only responses to high arousal positive and high arousal negative images. Interestingly, a previous study reported a very similar but temporally shifted dynamic by which intention to process affective meaning had an additive effect on EPN and an interactive effect on P3 amplifications (Schupp, Stockburger, Codispoti, et al., 2007). In that study, stimuli were presented rapidly in a consecutive stream and intentional affect processing was manipulated by category-determined target-status (e.g., count all aversive images vs. all images depicting people). It is possible that prolonged and/or more elaborate affective evaluations required by Study III design may have postponed the integration of unintentional or stimulus-driven and intentional or task-dependent prioritization of affect. Importantly, in Study III the nonaffective evaluation task did not fully eliminate the affective amplifications of any of the ERP components. This suggests that, at least without substantial cognitive load (cf., Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Schupp, Stockburger, Bublatzky, et al., 2007), the prioritization of affective stimuli remains to some extent unintentional.

Taken together, the findings of Study III confirm the idea that for motivated attention the degree of automaticity changes gradually across consecutive

[16] The residuals from linear regressions, partialling out the effects of stimulus luminance and energy in the high as well as low spatial frequency band on the variability of ERP amplitudes, were used instead of raw amplitudes to test the main and interactive effects of the five affective categories and the two evaluation conditions.

processing stages whereby earlier stages are characterized by more automatic allocation of attentional resources to affectively salient stimuli than later stages (e.g., Ferrari et al., 2008; Rellecke et al., 2012a; Schupp, Flaisch, et al., 2006; Schupp, Stockburger, Codispoti, et al., 2007). The findings also support the more general notion that automaticity should be viewed as gradual rather than binary and, in light of previous studies (e.g., Schupp, Stockburger, Codispoti, et al., 2007), that the degree of automaticity can depend on numerous factors influencing the representational quality of stimuli that are being processed (e.g., Melnikoff & Bargh, 2018; Moors, 2016).

3.2. Attentional mechanisms of affective individual differences

As described in Section 1.3., biases or alterations in motivated attention can be mechanistically involved in various affective individual difference constructs and, in accordance with the CPC framework, considering the moderating effects of contextual demands can help elucidate more specific dynamics. The dissertation will next demonstrate the applicability of the CPC framework by investigating the attentional mechanisms of two affective individual difference constructs – preoccupation with body image (Study IV) and mindfulness (Study V). Both studies will focus on the interplay between construct-relevant contextual demands and construct-relevant biases in motivated attention but will address also the automaticity of the biases.

3.2.1. Preoccupation with body image

Disturbed body image is a multicomponent construct that involves distorted perceptions of one's body (i.e., the perceptual component) as well as body-related negative affect and attitudes (i.e., the cognitive-affective component; Cash, 2004; Cash & Brown, 1987; Cash & Deagle, 1997; Thompson, 2004). Despite numerous detrimental outcomes, such as poor subjective quality of life (e.g., Mond et al., 2013) and elevated risk for the development of eating disorders (e.g., Stice et al., 2011), relatively little is known about the specific psychological mechanisms of disturbed body image.

The aim of Study IV was to clarify the attentional mechanisms of preoccupation with body image (Akkermann, 2010) – the cognitive-affective component of disturbed body image that involves body dissatisfaction, related negative emotions, as well as dysfunctional concern with one's looks (e.g., Cash, 2004; Thompson, 2004). Theoretical models as well as empirical studies focusing on related phenomena (e.g., Aspen et al., 2013; Faunce, 2002; Rodgers & DuBois, 2016; Williamson et al., 2004) suggest that attention biases toward appearance-information may be mechanistically implicated in preoccupation with body image. One appearance feature that is likely to be particularly salient for people with high preoccupation is body size (cf., Fairburn, Cooper, & Shafran, 2003; Williamson et al., 2004). Empirical evidence about the potential direction of preoccupation-related biases in body size processing, however, is mixed. Namely, related constructs have been associated with both increased and decreased prioritization of "fatness" and "thinness" cues (e.g., Horndasch, Heinrich, Kratz, & Moll, 2012; Mai et al., 2015; Rodgers & DuBois, 2016). One possibility for these inconsistencies is that many previous studies have not considered the role of contextual factors that might alter the subjective relevance of body size information.

One important contextual feature that could moderate preoccupation-related attention biases toward body size is the difference between self-observation and social comparison (e.g., Rodgers & DuBois, 2016). There is evidence that people with high body dissatisfaction tend to focus on others' attractive and own unattractive body areas (e.g., Blechert, Nickert, Caffier, & Tuschen-Caffier, 2009; Jansen, Nederkoorn, & Mulkens, 2005; Roefs et al., 2008). It is likely that similar self-deprecating biases operate in people with high pre-occupation during body size processing whereby they attend more to "thinness" cues in others and to "fatness" cues in self. The asymmetrical relevance of body size might originate from the tendency to assign undue significance to slim body shape (i.e., "thinness" cues in others as potential body-ideal targets) as well as be overly critical of oneself (i.e., "fatness" cues in self as indicators of shortcomings). From the CPC perspective, it is important to note that the context-dependent prioritization of body size could also be implicated in the phenotypical expression of preoccupation with body image. Namely, attending to perceived flaws in oneself and desired aspects in others could enforce the characteristic negative view of one's body (e.g., Cash, 2004; Thompson, 2004) as well as unrealistic body-ideals and norms (e.g., Glauert, Rhodes, Byrne, Fink, & Grammer, 2009).

It is also possible that previous inconsistencies in the literature about the relationship between disturbed body image and attention biases to body size originate from unaccounted differences between automatic and more controlled body size processing. Attention biases to appearance-related stimuli are generally considered to be fairly automatic in people with disturbed body image (e.g., Williamson et al., 2004) and should therefore be relatively automatic also in people with high preoccupation. However, the self-observation and the social comparison context might pose unique demands on more automatic and more controlled biases. Therefore, to elucidate the attentional mechanisms of pre-occupation with body image, both the context-dependency and the automaticity of attention biases to body size were investigated in Study IV of the current dissertation.

3.2.1.1. Study IV – Attention biases in preoccupation with body image: an ERP study of the role of social comparison and automaticity when processing body size

The main objective of Study IV was to investigate how preoccupation-related attention biases to body size are moderated by the context of self-observation vs. social comparison. Toward that end 36 women with high (n = 13) or low (n = 23) self-reported Preoccupation with body-image and body-weight (a subscale of the Eating Disorder Assessment Scale or EDAS; Akkermann, 2010) viewed size-modified images (from –10% to +10% in steps of 2%) of themselves and a figure-matched peer with the instruction to compare each image to the mental representation of their actual body size. The condition with self-images was designed to model **self-observation** context and the condition with peer-images was designed to model **social comparison** context. Attention biases toward body size were estimated from modulations to the mean amplitudes of ERP components N170, P2, P3 and LPP averaged for **enlarged images** (+4, +6, +8, and +10%), **naturalistic images** (+2, 0, and –2 %), and **reduced images** (–4, –6, –8, and –10%) with naturalistic images serving as the baseline category. The sensitivity of attention biases to the evaluation context was estimated by comparing responses to self-images and peer-images. It was hypothesized that the evaluation context moderates body size processing more in women with high preoccupation than in women with low preoccupation. More specifically, based on the prediction that preoccupied women exhibit self-deprecating biases when processing body size (cf., Blechert et al., 2009; Jansen et al., 2005; Roefs et al., 2008) their ERP responses were expected to be amplified the most by enlarged self-images and reduced peer-images.

The second objective of Study IV was to assess the automaticity of preoccupation-related attention biases. It was predicted that attention biases to body size modifications are more automatic in women with high preoccupation in the sense of greater processing speed and efficiency. The speed aspect of automaticity was inferred from the time course of ERP modulations, whereby biases emerging during earlier ERP components were deemed more automatic than biases emerging during later components. Additionally, the mass-univariate approach (Groppe, Urbach, & Kutas, 2011) was used to clarify the more precise temporal dynamics within the relatively long LPP time-window. The efficiency aspect of automaticity was investigated with a concurrent cued-recall working memory (WM) task that required memorizing a sequence of either two (i.e., **the low concurrent WM load condition**) or six (i.e., **the high concurrent WM load condition**) consonants for the duration of each body size comparison trial. From the efficiency perspective, biases that were insensitive to concurrent WM load were considered more automatic than biases that were reduced during the high load condition. The interactions between automaticity and context were analyzed in an exploratory manner.

Study IV findings supported the prediction that the evaluation context moderates attention biases to body size more in women with high preoccupation than in women with low preoccupation. Regarding the direction and the automaticity of biases, however, a more nuanced pattern was revealed. There was an interesting interaction between the processing speed and the context-dependency of body size processing. Namely, the attention biases to size modifications clustered into a context-insensitive early phase (i.e., N170 and P2) and a context-sensitive later phase (i.e., P3 and LPP). The evaluation context did not affect early and more automatic attention biases in either group but played a role in biasing the later and more controlled attention in pre-occupied women.

During the context-insensitive early phase, all participants exhibited an attention bias toward enlarged self-images as well as enlarged peer-images, as indicated by elevated fronto-central P2 responses. This early sensitivity to body size increases could reflect an automatic negativity bias (e.g., Carretié et al., 2001) and is in line with a previous study where schematic drawings of obese bodies increased fronto-central positivity (as well as occipito-temporal negativity) in a similar time-range (Schupp & Renner, 2011). Importantly, in the high preoccupation group enlarged images amplified also the temporal N170, albeit only under high concurrent WM load. Therefore, in preoccupied women the early prioritization of body size increases seems to be more automatic in terms of processing speed and may occur already during the structural encoding of body stimuli (Eimer, 2000; Thierry et al., 2006). However, in light of the unexpected interaction with the WM load and the fact that face-processing (faces were included in the stimuli for identity manipulation purposes) can impact early body-sensitive ERP components (e.g., de Gelder et al., 2010), the N170 finding should be interpreted with caution. There were no systematic effects of concurrent WM load, indicating that body size processing may be in general relatively efficient.

The prediction that women with high preoccupation exhibit self-deprecating biases when processing body size was not fully confirmed. Instead, during the context-sensitive later phase preoccupied women were characterized by faster and more pronounced biases toward enlarged self-images but also toward reduced self-images and a simultaneous lack of sensitivity to the size of the peer. Specifically, in the high preoccupation group enlarged self-images amplified both the fronto-central P3 and the centro-parietal LPP and the reduced self-images amplified the centro-parietal LPP, while no size-related modulations emerged for the peer-images. This suggests that for preoccupied women increases and decrease of their own body size were more salient, possibly due to greater negative and positive arousal (e.g., Cuthbert et al., 2000; Schupp, Cuthbert, et al., 2004; Weinberg & Hajcak, 2010), respectively. Women with low preoccupation, however, exhibited a relatively short-lived bidirectional sensitivity to body size modifications during the LPP time-window that was evident in both contexts. These differential dynamics suggest that a potential attentional mechanism of preoccupation with body image involves over-prioritization of own body size, particularly size increases, and under-prioritization of body size information in others (see also Figure 3).

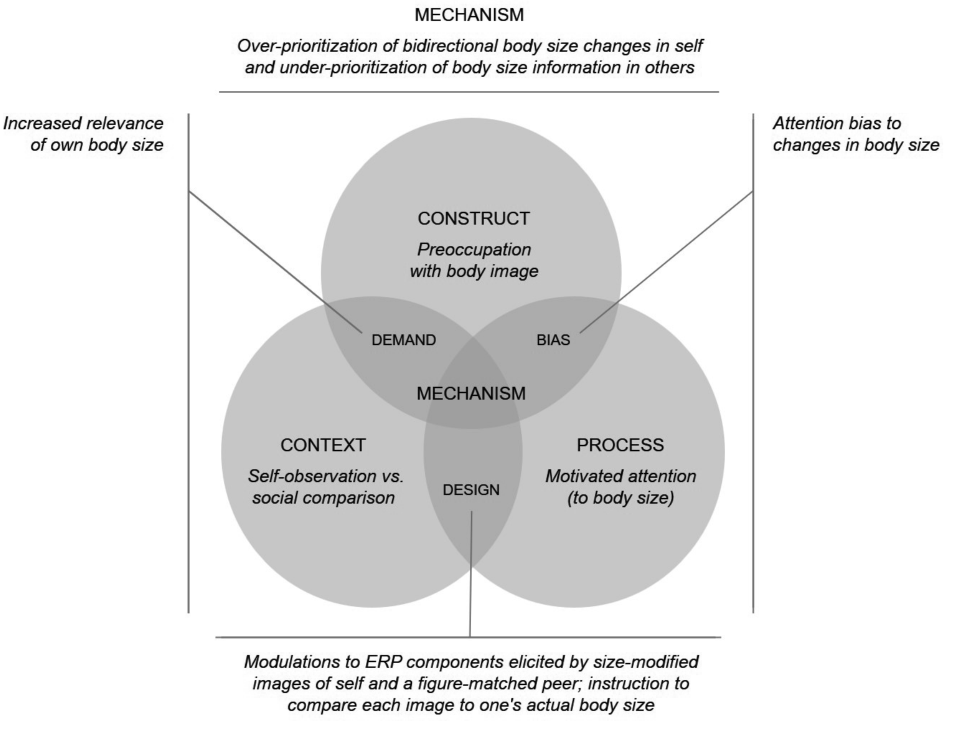

Figure 3. Summary of Study IV according to the CPC framework. The findings suggest that the over-prioritization of own body size and simultaneous under-prioritization of others' body size may constitute a psychological mechanism of preoccupation with body image.

The over-prioritization of own body size fits with the conceptualization of preoccupation (Akkermann, 2010) and is also in line with theoretical models of disturbed body image (e.g., Cash & Brown, 1987; Thompson, 2004; Williamson et al., 2004). The lack of sensitivity to peer body size during the more controlled processing stages, however, is a bit more puzzling finding. There are many potential underlying reasons that need to be clarified in dedicated studies. For instance, it is possible that preoccupied women were overly focused on the mental representation of their own appearance during the social comparison condition and therefore paid less attention to the peer-image during the capacity-limited stages of motivated attention (cf., Van den Eynde et al., 2013). However, considering that people with disturbed body image prefer to engage primarily in upward social comparisons (e.g., O'Brien et al., 2009; Schaefer & Thompson, 2014), a peer with a similar figure may simply not have been a preferred target of attention for that group. It is also possible that women with high preoccupation were more sensitive to modifications in own body size due to greater "expertise". As a result, the relatively small size differences presented in Study IV may have been salient when applied to the self but not when applied to a peer. Finally, women with high preoccupation may have exhibited different scanning patterns during the self-observation and the social comparison condition (cf., Jansen et al., 2005; Roefs et al., 2008) that could have impacted the relevance of size modifications. Regardless of the specific cause, preoccupation with body image seems to involve an over-engagement with own body size that may hinder social comparison with appropriate targets. The lack of sustained processing of peer body size, however, did not affect significantly the ability of preoccupied women to make accurate size comparisons with the peer[17]. Therefore, the deficiencies in social comparison processes are likely affective in nature.

In summary, the findings of Study IV suggest that the over-prioritization of own body size and simultaneous under-prioritization of others' body size may constitute a psychological mechanism of preoccupation with body image. Importantly, both the over-prioritization of own body size and the under-prioritization of others' body size have the potential to be implicated in the phenotypical expression of preoccupation. Namely, being very attentive toward changes in own body size may reinforce the subjective relevance of slim figure and low weight as well as critical attitudes toward one's appearance. At the same time, not attending to the body size of peers with similar figures may obstruct adequate comparisons (cf., Glauert et al., 2009) thereby limiting the potential to correct the negative evaluations of oneself.

3.2.2. Mindfulness

Mindfulness can be defined as a state of nonelaborative and nonjudgmental awareness, arising from paying attention to the present-moment experience with the attitude of curiosity and acceptance (Bishop et al., 2004; Brown & Ryan, 2003; Farb, Anderson, Irving, & Segal, 2014; Kabat-Zinn, 1990; Shapiro, Carlson, Astin, & Freedman, 2006). Importantly for the current dissertation, there are relatively stable patterns in the frequency and ease with which people enter the state of mindfulness. Therefore, the tendency to be mindful can be thought of as an affective individual difference. Two types of mindfulness-related individual difference constructs have been distinguished (e.g., Rau & Williams, 2016): dispositional or trait mindfulness refers to a naturally occurring trait-like characteristic (e.g., Baer et al., 2006; Brown & Ryan, 2003) and cultivated mindfulness refers to a set of skills developed through practice (e.g., Kiken, Garland, Bluth, Palsson, & Gaylord, 2015; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008). Despite different origins, both high levels of trait and cultivated mindfulness have been linked to improved affective functioning (e.g., Baer, 2003; Brown & Ryan, 2003; Hayes & Feldman, 2004; Keng et al., 2011; Khoury et al., 2015), including reduced emotional reactivity (e.g., Arch & Craske, 2006; Brown et al., 2013; Lutz et al., 2014). The more

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[17] See Supplementary materials of Study IV for more information about behavioral results.

specific psychological mechanisms through which mindfulness influences affective experiences, however, are not yet fully understood.

It has been suggested that one important mindfulness-related affective benefit is the de-automatization of emotional responding (e.g., Kang, Gruber, & Gray, 2013) whereby all experiences, regardless of their valence, are processed in a more detailed and deliberate manner (e.g., Chambers, Gullone, & Allen, 2009). In terms of motivated attention, this would manifest as reduced prioritization of affective information (e.g., Brown et al., 2013). One possible mechanistic pathway through which mindfulness could de-automate emotional reactions is affective adaptation i.e., the process of weakening habitual emotional responses over time (Frederick & Loewenstein, 1999; Wilson & Gilbert, 2008). It has been suggested that mindfulness improves affective adaptation by facilitating exposure, extinction, and reconsolidation. More specifically, increased engagement with emotional experiences, induced by mindful attention and acceptance, is thought to promote gradual weakening of habitual responses to the point where the emotional trigger obtains a more neutral meaning in the long-term memory (e.g., Farb et al., 2014; Hölzel et al., 2011; Shapiro et al., 2006).

There is evidence that mindfulness can involve different mechanisms in different populations. For instance, redeploying attention to present moment experience in an accepting manner requires cognitive control in novices but is fairly effortless in experienced meditators as well as laypeople with high dispositional mindfulness (Brown et al., 2007; Chambers et al., 2009; Chiesa, Serretti, & Jakobsen, 2013; Hölzel et al., 2011; Taylor et al., 2011). This suggests that affective adaptation is mainly a mechanism of cultivated mindfulness with particular relevance during the early stages of training (cf., Lindsay & Creswell, 2017). Therefore, Study V of the current dissertation investigated whether mindfulness is related to increased affective adaptation by inducing mindfulness state in people with no or minimal meditation experience. To capture potential interindividual variation in the rate of affective adaptation, self-reported trait mindfulness was also assessed and related to the dynamics of induced mindfulness state.

3.2.2.1. Study V – Mechanisms of mindfulness: the dynamics of affective adaptation during open monitoring

The specific aim of Study V was to test the prediction that mindfulness is related to improved affective adaptation as indicated by increased exposure to emotional experiences, faster extinction of habitual emotional responses, and more sustained reconsolidation of reduced affective salience (e.g., Hölzel et al., 2011). It is likely that adaptation has a broad impact on affective experiences. However, given the centrality of attention orienting in mindfulness (e.g., Bishop et al., 2004), Study V focused on motivated attention.

Thirty-seven volunteers with no or limited mindfulness experience underwent an emotion elicitation task where they were instructed to view blocks of neutral and negative IAPS images (Lang et al., 2008) mindfully and during two control conditions[18]. During **the mindful-viewing condition** mindfulness state was elicited with an open-monitoring instruction guiding the participants to pay attention to all arising thoughts, feelings, and bodily sensations in an accepting manner without trying to change them. During **the attentive-viewing condition** participants were instructed to pay attention to the details of each picture. This control condition was designed to model engagement with emotional triggers without the components of mindfulness (i.e., the present-moment focus and the acceptance of experience). During **the distraction condition** participants were asked to perform a simple backward counting task while viewing the images. The distraction condition was designed to model disengagement form both emotional triggers and the affective experience[19].

The temporal dynamics of affective adaptation suggest that the novelty vs. familiarity of emotional triggers is an important contextual factor to consider. For that reason, both neutral and negative images were presented repeatedly in every condition (i.e., the **three implementation repetitions**) to assess **exposure** as well as gradual **extinction**. After completing the implementation repetitions of every condition participants were re-exposed to all previously viewed images with the instruction to look at each image and rate their subjective experience. This **re-exposure repetition** was designed to capture **reconsolidation**.

The analyses focused on the affective LPP amplification (i.e., the difference between LPP responses to negative and neutral stimuli) that currently reflects the preferential processing of negative information and has been shown to be resistant to simple habitation effects (Codispoti, Ferrari, & Bradley, 2006, 2007; Mastria, Ferrari, & Codispoti, 2017; Schupp, Stockburger, et al., 2006)[20]. Mindfulness-related increase in exposure was expected to manifest as larger affective amplification of mean LPP amplitude during the first repetition of the mindful-viewing condition, the faster extinction as more rapid reduction of the amplification during subsequent repetitions, and the more sustained reconsolidation as smaller amplification during the re-exposure. To clarify the degree to which different conditions modulated relatively more automatic vs. relatively more controlled preferential processing of negative stimuli, the temporal dynamics of affective modulations were also analyzed using the mass-univariate approach (Groppe et al., 2011). Based on the findings of Study III, modifications to the earlier segment of the LPP were considered to capture alterations in more

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[18] The appropriateness of heterogeneous sets of IAPS images for eliciting interindividual differences in motivated attention was supported by the findings of Study I whereby a small but statistically significant portion of the LPP amplitude variance was explained by stimulus-dependent interindividual variability.

[19] Full instructions for every condition are presented in Study V Supplementary Materials.

[20] The need to focus on affective amplifications (i.e., the neutral vs. negative contrast) was supported by Study I LPP results whereby a large portion of LPP variance in response to IAPS images stemmed from stimulus independent interindividual variance.

automatic attention allocation. Mindfulness related de-automatization was expected to manifest as earlier effects compared to control conditions. In addition to the experimental manipulation of mindfulness state, trait mindfulness was assessed with the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003; Seema et al., 2014). It was predicted that people with higher self-reported trait mindfulness exhibit augmented affective adaptation during open monitoring (i.e., even greater exposure, faster extinction, and more sustained reconsolidation).

In support of the main hypothesis, mindfulness induction was characterized by improved affective adaptation compared to the two control conditions. As predicted, the affective LPP amplification was largest during the first repetition of the mindful-viewing condition. This effect was driven by enhanced responses to negative images, suggesting higher salience of affective information and increased exposure (cf., Arch & Craske, 2006, 2010; Kumar, Feldman, & Hayes, 2008; Watford & Stafford, 2015). The affective LPP amplification was notably reduced during the second repetition and completely removed during the third repetition of the mindful-viewing condition. The extinction dynamics were less prominent during the attentive-viewing condition and absent during the distraction condition. The between-condition contrast suggests that the open monitoring induction speeded up the extinction process with regards to preferentially processing of negative information. This finding is in line with and extends previous reports of mindfulness fostering physiological and subjective emotional recovery (Broderick, 2005; Campbell-Sills, Barlow, Brown, & Hofmann, 2006). Unlike stimuli from other conditions, mindfully viewed negative and neutral images did not elicit significantly different LPP responses during the later re-exposure repetition. This suggests that the mindfulness-related reduction of the relative salience of negative stimuli was retained over a short period of time, supporting the more sustained reconsolidation prediction.

It is important to note that the extinction of the relative salience of negative stimuli observed in the mindful-viewing condition resulted from gradually decreasing responses to negative images as well as gradually increasing responses to neutral images. It is possible that increases in neutral LPP reflected stimulus recognition (e.g., Ferrari, Codispoti, & Bradley, 2017; Rugg & Curran, 2007). However, the “old-new” effect has been typically reported for affective not neutral stimuli (e.g., Ferrari, Bradley, Codispoti, Karlsson, & Lang, 2013). Alternatively, neutral images may have captured more attention over time. The latter dynamic would be in line with the idea that mindfulness leads to more focused processing of all experiences, regardless of their valence (e.g., Chambers et al., 2009).

The temporal dynamics of the affective LPP amplification provided some support to the hypothesis that mindfulness may be related to de-automatization of emotional responding (e.g., Kang et al., 2013). Namely, while the affective amplification of the later portion of the LPP was gradually reduced in the mindful-viewing and the attentive-viewing conditions alike, the elimination of earlier LPP amplification charactreized only the mindful-viewing condition.

This suggests that over time open monitoring mindfulness induction attenuated not only the relatively controlled but also the relatively more automatic prioritization of emotional stimuli.

Finally, the hypothesis that trait mindfulness enhances open monitoring related affective adaptation was only partially supported. People with higher trait mindfulness exhibited smaller affective amplification when they were re-exposed to images from the mindful-viewing condition. This suggests that higher trait mindfulness further facilitated the reconsolidation of reduced affective salience. Somewhat surprisingly, there were no relationships between trait mindfulness and the exposure or extinction dynamics of the mindful-viewing condition[21]. It is therefore possible that affective adaptation is not related to dispositional mindfulness. Alternatively, the MAAS questionnaire used in Study V may not have captured mindfulness-related individual differences that are central to affective adaptation. According to the Monitor and Accept Theory (Lindsay & Creswell, 2017) it is the acceptance component of mindfulness training that drives the reduction of affective reactivity. Because MAAS captures only the attentional component of trait mindfulness, it may have missed interindividual variation relevant for affective adaptation. Multicomponent mindfulness measures, such as the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008), that put more emphasis on individual differences in acceptance, might yield different associations.

In summary, the findings of Study V suggest, that the link between mindfulness and reduced prioritization of negative information is not unequivocal, at least not in novices. Instead, the time course of an affective episode and/or previous experience with the trigger seem to be important contextual factors that moderate the relationship between cultivated mindfulness and motivated attention. Open monitoring mindfulness induction seems to initially increase the salience of affective signals. Over subsequent encounters, however, the salience is reduced to the point where affectively valenced information is no longer prioritized. Furthermore, the reduced salience may be somewhat lasting, extending beyond the deliberate implementation of open monitoring. Together these time-course dependent alterations suggest that increased affective adaptation is a potential psychological mechanism of cultivated mindfulness (see also Figure 4). It remains to be tested in future studies but improvements in affective adaptation may be the reason why mindfulness training reduces and de-automates emotional responding.

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[21] Trait mindfulness was also not related to the affective LPP amplifications observed during the attentive-viewing or the distraction condition.

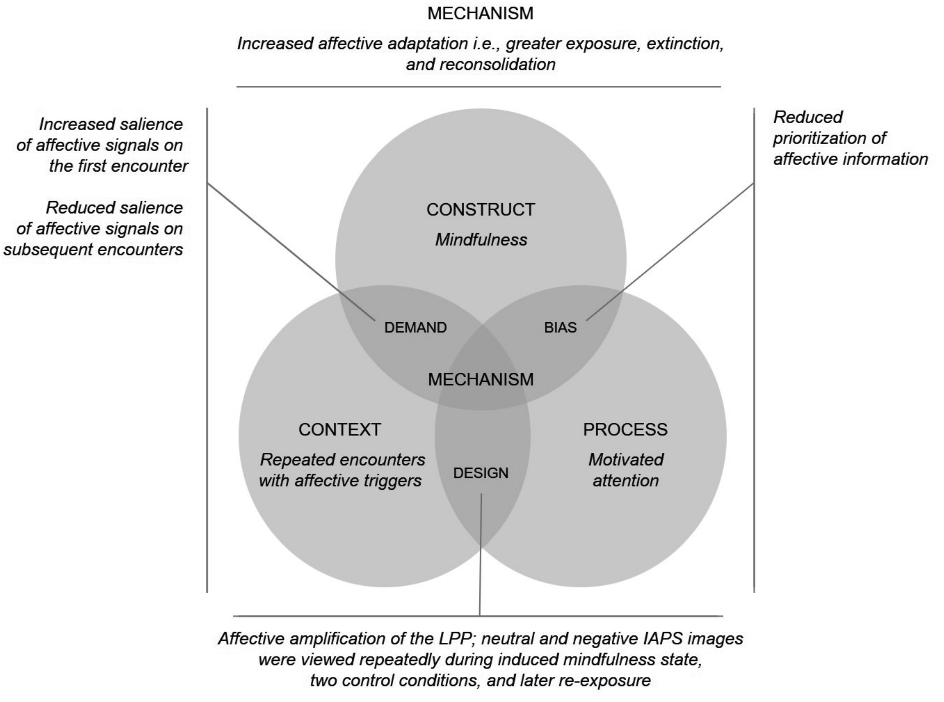

Figure 4. Summary of Study V according to the CPC framework. The findings suggest that increased affective adaptation, as indicated by greater exposure, faster extinction, and more sustained reconsolidation, may constitute a psychological mechanism of cultivated mindfulness. Namely, in the context of repeated encounters with emotional triggers, induced mindfulness state seems to be characterized by an initial increase and subsequent decrease in the salience of affective information.

3.3. Interim summary

A large body of evidence confirms the appropriateness of ERP components for evaluating the prioritization of motivationally significant information across consecutive processing stages from stimulus detection and encoding to more complex cognitive elaborations (Hajcak et al., 2011; Olofsson et al., 2008; Pourtois et al., 2013; Schupp, Flaisch, et al., 2006). The ERP-methodology can therefore offer valuable insights into the attentional mechanisms of affective individual differences.

The high temporal resolution of EEG means that ERP components can also provide a rough estimate about the automaticity of specific mechanisms. Based on the observations that automatic processes unfold faster than non-automatic processes (e.g., Moors, 2016; Moors & De Houwer, 2006), the affective amplification of earlier ERP components is considered to indicate relatively more automatic and the affective amplification of later ERP components is considered to indicate relatively less automatic prioritization of motivationally significant information (Hajcak et al., 2010; Pessoa, 2005; Pourtois et al., 2013; Schupp, Flaisch, et al., 2006; Vuilleumier, 2005).

Studies IV and V of the current dissertation applied the principles of the CPC framework to clarify the link between motivated attention and two affective individual difference constructs – preoccupation with body image and mindfulness. Both studies inferred motivated attention from modulations of ERP components and utilized the temporal resolution of EEG to address the automaticity of characteristic dynamics. But first, Study III of the current dissertation replicated and extended known aspects of the relationship between affect-sensitive ERP components and the automaticity of motivated attention by investigating the transition from relatively unintentional to relatively intentional prioritization of affect.

In Study III the preferential encoding of affective information, captured by EPN, was found to be unintentional. The subsequent consolidation and elaboration of stimulus representations, captured by the P3 and the SW portions of the LPP, remained sensitive to stimulus-driven or unintentional attention but were increasingly modulated by the intention to process affective meaning. This suggests that unintentional and intentional prioritization of affect integrate gradually across consecutive processing stages. The speed of this integration may depend on contextual factors (cf., Schupp, Stockburger, Codispoti, et al., 2007) and other automaticity features may not go inside with intentionality (e.g., Melnikoff & Bargh, 2018). Nonetheless, the findings of Study III support the general idea that relative automaticity of motivated attention can be estimated from the temporal dynamics of affective ERP amplifications.

Study IV investigated whether preoccupation-related attention biases to body size are moderated by the context of self-observation vs. social comparison and whether the two evaluation contexts pose unique demands on more automatic and more controlled prioritization of body size information. The findings revealed that the evaluation context did not affect early and relatively more automatic processing of body size information, captured by N170 and P2. During that stage preoccupied women were characterized by faster prioritization of body size increases. In preoccupied women the evaluation context did moderate, however, the later and relatively less automatic body size processing, captured by P3 and LPP. Namely, women with high preoccupation were characterized by over-prioritization of own body size and under-prioritization of peer body size. Form the methodological perspective, Study IV is a clear example why considering the effects of contextual factors may be important for clarifying the psychological mechanisms of affective individual differences. Without contrasting self-images to peer-images the conclusions about preoccupation-related attention biases to body size would have been markedly different. The use of peer-images or de-identified images would have likely indicated initial hypervigilance toward and later avoidance of enlarged bodies. The use of self-images alone would have indicated a stronger and faster bias toward enlarged bodies. Only by considering the contextual effects of self-observation and social comparison were the respective over- and under-prioritization of size information during later processing stages revealed.

Study V investigated the psychological mechanisms of mindfulness. The mechanisms of mindfulness have been shown to vary in different populations. Study V focused on cultivated mindfulness and did so by inducing mindfulness state in participants with no or limited meditation experience using an open monitoring instruction. The LPP findings of Study V suggest that increased affective adaptation may be one of the mechanisms through which cultivated mindfulness reduces and de-automates affective reactivity. Namely, in the context of repeated encounters with emotionally evocative stimuli, induced mindfulness state was characterized by an initial increase and subsequent decrease in the salience of affective information that lasted beyond the immediate implementation of open monitoring. Importantly, over time mindfulness reduced not only the later and more controlled but also the earlier and more automatic prioritization of negative stimuli. From the perspective of the CPC framework, Study V illustrates how contextual factors that may be relevant for clarifying the psychological mechanisms of affective individual differences are not limited to the current state of the world but can also entail previous experiences.

4. GENERAL SUMMARY AND CONCLUSIONS

The current dissertation presented the Construct-Process-Context (CPC) framework as a conceptual tool for studying the psychological mechanisms of affective individual differences. The central premise of the CPC framework is that the psychological mechanisms of affective individual difference constructs can involve certain affective processes becoming altered in a context-dependent manner. The framework therefore suggests that specific psychological mechanisms are best detectable at the intersection of construct-relevant processing biases and contextual demands using experimental designs that capture the interaction between the process and the context of interest. Importantly, the CPC framework does not claim that all psychological mechanisms of affective individual differences are context-dependent. It simply emphasizes that the role of contextual factors should be carefully considered and/or systematically manipulated.

The main body of the dissertation focused on testing the applicability of the CPC framework by investigating potential mechanisms of affective individual differences that involve either the activation of approach-avoidance motivation or motivated attention. Approach-avoidance motivation was inferred from anterior EEG asymmetry and motivated attention from affective amplifications of ERP components.

Two of the five empirical studies (Studies I and III) clarified open methodological questions to inform the design and interpretation of individual difference studies. Study I demonstrated that heterogeneous sets of affective images may be ill-suited to investigate individual differences in approach-avoidance motivation with anterior EEG asymmetry. Instead, more salient stimuli should be used that have the capacity to elicit action tendencies or action readiness. Study III clarified the relationship between affect-sensitive ERP components and the automaticity of motivated attention by demonstrating that the transition from relatively unintentional to relatively intentional prioritization of affective information is gradual and may depend on contextual factors. The gradual nature of the transition means that the automaticity of motivated attention can be estimated based on the temporal dynamics of affective ERP amplifications but should be viewed and described in relative terms.

The other three empirical studies demonstrated how careful operationalization of theoretically motivated processing biases and contextual demands helps to improve the understanding of specific psychological mechanisms of different affective individual difference constructs, namely Neuroticism (Study II), preoccupation with body image (Study IV), and cultivated mindfulness (Study V).

Using a novel paradigm involving social contact with a real person altering her gaze direction, Study II demonstrated that high Neuroticism is related to the activation of avoidance tendencies in response to another person's directed attention (i.e., direct gaze). Experiencing avoidance motivation in response to neutral social contact could potentially reduce the quality of social interactions and increase negative affectivity in people with high Neuroticism.

The findings of Study IV suggest that during later and relatively more controlled stages of motivated attention, high preoccupation with body image may involve over-prioritization of own body size and under-prioritization of peer body size. This kind of asymmetrical processing of body size information may reinforce critical attitudes toward and dysfunctional concern with own appearance, that characterize people with high preoccupation.

Finally, Study V demonstrated that mindfulness is related to improved affective adaptation, as indicated by increased exposure to emotional experiences, faster extinction of habitual emotional responses, and more sustained reconsolidation of reduced affective salience. It is possible that facilitation of affective adaptation is one of the mechanisms through which mindfulness training leads to reduced and less automatic emotional responding.

Importantly, Studies II, IV, and V focused on interactions between the individual difference construct, the process, and the context. These interactions can be thought of as candidates for specific psychological mechanisms of respective affective individual differences. The actual mechanistic nature of the interactions (i.e., the degree to which they contribute to the phenotypical expression of the predispositions) was not assessed and needs to be established in future studies.

Regardless, the studies featured in the current dissertation illustrate how consideration of theoretically motivated contextual moderators can reveal more specific psychological mechanisms of various affective individual differences. As is the case with Studies II and IV, it can also offer a resolution to apparent inconsistencies in the existing literature. Therefore, the principles summarized in the CPC framework could be used to systematize existing evidence as well as plan future empirical research on the psychological mechanisms of affective individual differences. Future research may also consider extending the scope of the CPC framework by applying the same principles to the mechanisms of other individual differences.

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EESTIKEELNE KOKKUVÕTE

Afektiivsete individuaalsete erinevuste psühholoogiliste mehhanismide uurimine EEG korrelaatidega

Erinevate afektiivsete seisundite – emotsioonid, meeleolu, motivatsioonilised impulsid ja stressreaktsioonid – oluline ühendav joon on keskkonnas ohtude ja võimaluste tuvastamine ning asjakohase vastuse käivitamine (Gross, 2014; Moors, 2009; Scherer, 1984). Ühisele funktsioonile vaatamata võivad inimeste afektiivsed kogemused, ehk teisisõnu tundeelu, olla väga erinevad. Afektiivsete kogemuste erinevused ei ole juhuslikud, vaid neid iseloomustavad rohkem ja vähem stabiilsed kalduvused teatud seisundite kogemiseks. Antud kalduvusi võib kõige laiemalt nimetada afektiivseteks individuaalseteks erinevusteks (Reisenzein ja Weber, 2009; Scherer jt, 2004). Afektiivsete individuaalsete erinevuste alla kuuluvad nii käitumist ja tundeelu laialt mõjutavad püsivad isiksuseomadused, nagu näiteks kõrge Neurootilisus (Costa ja McCrae, 1995), kui ka piiritletuma mõjuga ja veidi muutlikumad omadused, nagu näiteks kõrge hõivatus enda kehakaalust ja välimusest (Akkermann, 2010; Cash jt, 2002; Thompson, 2004). Samuti liigituvad afektiivsete individuaalsete erinevuste alla õpitavad või treenitavad omadused, nagu näiteks kõrge teadveloleku tase ehk kalduvus hinnanguvabaks teadlikkuseks enda hetkekogemusest (Brown ja Ryan, 2003; Brown jt, 2007).

Loetletud näited ja veel paljud teised afektiivsed individuaalsed erinevused on seotud oluliste aspektidega inimese psühholoogilises ja sotsiaalses toimimises. Kõrge Neurootilisus on muuhulgas seotud kõrgema psüühikahäirete riskiga (Kotov jt, 2010; Lahey, 2009; Ormel, Jeronimus, jt, 2013) ja kalduvusega olla vähem rahul enda sotsiaalsete suhetega (Ozer jt, 2006). Kõrge hõivatus kehakaalust ja välimusest on seotud ebatervislike kaalulangetusmeetodite kasutamisega (Neumark-Sztainer jt, 2006) ja kõrgema söömishäirete riskiga (Stice jt, 2011; Williamson jt, 2004). Kõrge teadveloleku tase on aga seotud madalama psüühikahäirete riskiga (Brown ja Ryan, 2003; Cash ja Whittingham, 2010) ning madalama emotsionaalse reaktiivsusega (Arch ja Craske, 2006; Brown jt, 2013; Lutz jt, 2014). Selleks, et mõista, kuidas antud seosed kujunevad ja kas ning kuidas oleks võimalik neid muuta, on oluline välja selgitada individuaalsete erinevuste psühholoogilised mehhanismid. Psühholoogiliste mehhanismide all peetakse väitekirjas silmas psühholoogiliste protsesside toimimise eripärasid, mis viivad iseloomulike avalduste väljendumiseni käitumuslikul ja kogemuslikul tasandil.

Käesolev väitekiri pakub varasema kirjanduse põhjal välja mudeli, mille abil afektiivsete individuaalsete erinevuste psühholoogilisi mehhanisme mõtestada ja uurida. Mudel eeldab, et afektiivsete individuaalsete erinevuste psühholoogilised mehhanismid võivad seisneda kontkestist sõltuvates muutustes afektiivsetes protsessides. Mudel keskendub seega afektiivse individuaalse erinevuse konstrukti, afektiivse protsessi eripära ja kontekstuaalsete tegurite kokkupuutealale ning kannab sellest lähtuvalt nime Konstrukti-Protsessi-Konteksti

(KPK) mudel. KPK rõhutab, et isegi kui konkreetne psühholoogiline mehhanism ei ole kontekstist sõltuv, on oluline seda võimalust süstemaatiliselt kontrollida. Sellest lähtuvalt soosib mudel eksperimentaalse meetodi ja afektiivsete protsesside objektiivsete markerite kasutamist.

Lisaks KPK mudeli ja selle teoreetilise tausta tutvustamisele esitleb väitekiri viie empiirilise uurimistöö tulemusi. Uurimistööde ühendav eesmärk on illustreerida KPK mudeli rakendusvõimalusi erinevate afektiivsete individuaalsete erinevuste psühholoogiliste mehhanismide kaardistamisel. Väitekirja uurimistööd keskenduvad individuaalsetele erinevustele, mille mehhanismid seisnevad kahe keskse afektiivse protsessi – lähenemis- või vältimismotivatsioon ja motivatsiooniline tähelepanu – eripärades. Lähenemis- või vältimismotivatsioon on motivatsiooniline kalduvus, mis annab afektiivsetele seisunditele käitumusliku suuna (Harmon-Jones, 2003; Norris jt, 2010). Motivatsiooniline tähelepanu on emotsionaalse tähendusega või muul moel motivatsiooniliselt olulise informatsiooni eelistatud töötlemine (Lang jt, 1997; Vuilleumier, 2005). Väitekirja uurimistöödes hinnati mõlemat protsessi aju elektrilist aktiivsust mõõtva elektroentsefalograafia (EEG) abil. Lähenemis- või vältimismotivatsiooni hinnatati EEG eesmise ehk frontaalse asümmeetria abil (Allen jt, 2004; Davidson, 1992b; Harmon-Jones ja Gable, 2018) ning motivatsioonilist tähelepanu EEG sündmuspotentsiaalide abil (Hajcak jt, 2011; Olofsson jt, 2008; Schupp jt, 2006).

Kaks empiirilist uurimistööd keskendusid lähenemis- või vältimismotivatsiooni ja motivatsioonilise tähelepanu katselise uurimise metodoloogilistele aspektidele. Uuringu I tulemused näitasid, et afektiivse sisuga pildid (Lang jt, 2008), mida kasutatakse palju motivatsioonilise tähelepanu uurimiseks, ei sobi eesmise EEG asümmeetria abil lähenemis- ja vältimismotivatsiooni hindamiseks. Tõenäoliselt ei tekita antud stiimulite vaatamine tugevaid käitumiskalduvusi, mis on lähenemis- või vältimismotivatsiooni avaldumiseks olulised (Harmon-Jones jt, 2010). Uuring III täpsustas motivatsioonilise tähelepanu automaatsuse seoseid erinevate EEG sündmuspotentsiaali komponentidega, keskendudes tahtlikkusele, mis on automaatsuse üks omadustest (Bargh, 1994; Moors, 2016). Tulemused näitasid, et stiimulite afektiivse tähenduse tahtmatu ja tahtlik eelistöötlus kombineeruvad ajas järk-järguliselt (Schupp jt, 2006). Kiire afektiivsete stiimulite eelistöötlus esimese paarisaja millisekundi jooksul näib olevat suuresti tahtmatu. Veidi aeglasem töötlus kuni paari sekundi jooksul on aga juba osaliselt tahtlikult suunatav.

Kolm ülejäänud empiirilist uurimistööd keskendusid erinevate afektiivsete individuaalsete erinevuste motivatsiooniliste või tähelepanuliste mehhanismide tuvastamisele. Uuring II kaardistas Neurootilisuse seoseid sotsiaalses kontekstis kogetava lähenemis- ja vältimismotivatsiooniga. Selleks mõõdeti EEG eesmist asümmeetriat olukorras, kus uuringus osalejad istusid vastakuti teise inimesega, kes vaatas erinevates katsetingimustes neile otsa, pööras pilgu kõrvale või sulges silmad. Tulemused näitasid, et kõrge Neurootilisusega inimestes tekitab silmside vältimismotivatsiooni. Selle põhjus võib seisneda suuremas ebakindluses või eneseteadlikkuses, mis avaldub kõrge Neurootilisusega inimestes isegi neutraalses olukorras kellegi tähelepanu objektiks olemisel. Neurootilisus oli seotud ka lühiajalisema vabatahtliku silmsidega ja pööratud pilgu positiivsemalt tajumisega, mis kinnitavad EEG tulemuste tõlgendust. On võimalik, et neutraalses sotsiaalses olukorras vältimismotivatsiooni kogemine on seotud kõrget Neurootilisust iseloomustava negatiivse afektiivsusega (Markon jt, 2005) ja sotsiaalsete suhete madalama tajutud kvaliteediga (Ozer jt, 2006).

Uuring IV tegeles küsimusega, kuidas seostub hõivatus kehakaalust ja välimusest tähelepanu kalletega kehasuuruse hindamisel. Täpsemalt uuriti, mil määral sõltuvad need tähelepanu kalded sotsiaalse võrdluse kontekstist (Rodgers ja DuBois, 2016) ning mil määral võib neid pidada automaatseks. Uuringus osalenud naised vaatasid kehasuuruse poolest muudetud pilte endast ja sarnase figuuriga võõrast naisest. Iga pildi puhul hindasid nad kujutatud keha suurust võrrelduna enda keha tegeliku suurusega. Piltide vaatamise ajal mõõdeti EEG sündmuspotentsiaalide abil suurendatud ja vähendatud kehade tähelepanulist eelistöötlust. Tulemused näitasid, et kõrge hõivatus seostub varajasemas ja automaatsemas töötlusfaasis kiirema suurendatud kehade eelistöötlusega, olenemata sellest, kas hinnati pilte enda või teise naise kehast. Hilisemas ja vähem automaatses töötlusfaasis avaldusid aga kontekstitundlikud eripärad – kõrge hõivatusega naised pöörasid enam tähelepanu enda kehasuuruse muutustele ja eirasid teise naise kehasuuruse muutusi. Need tulemused näitavad, et enda keha tähelepanuline ületähtsustamine sotsiaalseks võrdluseks sobilike kehade arvelt võib olla üks hõivatuse psühholoogilistest mehhanismidest.

Uuring V keskendus teadveloleku mehhanismide uurimisele. Teadvelolek viitab nii seisundilisele hinnanguvabale teadlikkusele hetkekogemusest (Bishop jt. 2004; Kabat-Zinn, 1990; Shapiro jt. 2006) kui ka püsivamale kalduvusele antud seisundit kogeda. Viimase puhul võib omakorda eristada kaasasündinud omapära (Baer jt. 2006; Brown ja Ryan, 2003) ja arendatavat oskust (Kiken jt. 2015; Shapiro jt. 2008). Täpsemalt otsis Uuring V vastust küsimusele, kas teadveloleku treenimine võiks olla seotud kiirema ja kestvama afektiivse adaptatsiooniga (Hölzel jt, 2011) ehk afektiivsete reaktsioonide vähenemisega ajas. Osalejatel, kes polnud varem teadveloleku treeninguga kokku puutunud, paluti teadveloleku seisundis vaadata neutraalseid ja negatiivseid pilte. Et hinnata afektiivsete reaktsioonide muutumist ajas, näidati samu pilte korduvalt ja hinnati EEG sündmuspotentsiaalide abil negatiivsete stiimulite eelistöötluse määra. Teadveloleku seisundi tekitamiseks juhendati osalejaid piltide vaatamise ajal enda kogemust hinnanguvabalt jälgima. Seda seisundit kõrvutati kahe kontrolltingimusega, millest ühes juhiti osalejate tähelepanu piltidele ja teises kõrvalisele ülesandele. Tulemused näitasid, et võrreldes kontrolltingimustega iseloomustas teadveloleku seisundit negatiivsete stiimulite eelistöötluse esialgne võimendumine ja sellele järgnev kiire vähenemine. Teadveloleku seisundis oli piltide kolmandaks vaatamiskorraks negatiivsete töötluseelis neutraalsete ees kadunud. Mis veelgi olulisem, erinevused puudusid ka siis, kui osalejatele näidati katse teises osas samu stiimuleid ilma teadveloleku juhendita. Seega kinnitasid Uuring V tulemused hüpoteesi, et afektiivse adaptatsiooni kiirenemine võib olla üks teadveloleku mehhanismidest.

Tervikuna illustreerivad Uuringud II, IV ja V, et kontekstuaalsete teguritega arvestamine võib olla oluline spetsiifiliste psühholoogiliste mehhanismide tuvastamiseks. Uuringus II oli Neurootilisusega seotud vältimismotivatsiooni ilmnemisel määravaks teguriks sotsiaalne kontakt. Uuringus IV oli hõivatusega seotud tähelepanuliste kallete ilmnemisel oluline sotsiaalne võrdlus. Uuringus V oli teadveloleku ja negatiivsete stiimulite tähelepanulise eelistöötuse seoste tuvastamisel oluline ajaline dünaamika. Need tulemused annavad alust arvata, et KPK mudelist võib olla kasu ka teiste afektiivsete individuaalsete erinevuste psühholoogiliste mehhanismide uurimisel.

PUBLICATIONS

CURRICULUM VITAE

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2010–2018 Doctoral studies, University of Tartu, Institute of Psychology Includes a semester at Tampere University, Finland (January – May 2011) and three years at Stanford University, CA, USA (September 2015 – June 2018) as a visiting graduate researcher

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2005–2008 Bachelor of Arts (BA), University of Tartu, Institute of Psychology

Professional employment:

2011–… Research specialist, University of Tartu, Institute of Psychology

2011 Junior researcher, University of Tampere, Finland

2010–2015 Psychologist, Katriito Counselling and Psychotherapy Centre

Membership of professional organizations:

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Publications:

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