THE EFFECT OF EXECUTIVE CONTROL TRAINING ON EMOTIONAL DISTRACTION DURING CONFLICT RESOLUTION: A PUPILLOMETRY STUDY

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

THE EFFECT OF EXECUTIVE CONTROL TRAINING ON EMOTIONAL DISTRACTION DURING CONFLICT RESOLUTION: A PUPILLOMETRY STUDY

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Task-irrelevant emotion distracts executive processing on the one hand and executive control suppresses emotional processing on the other. This reciprocal cognition-emotion link underlies emotion regulation, which is critical for mental health. The present dissertation investigated the intricate relationship between cognitive load and emotional distraction, using non-emotional executive control training and taking mood-related effects into account. Two groups of participants were either trained on a high-load conflict resolution task or completed a low-load simple identification task. Both groups then completed an intermediate-load conflict resolution task with (Experiment 1) and without (Experiment 2) distracters. Distracter pictures were manipulated considering both valence and arousal dimensions. During training session and subsequent experiments, participants' accuracy scores, reaction times, and pupil diameters were recorded. At the behavioral level, the results of Experiment 1 revealed impaired performance in the presence of all task-irrelevant emotional pictures irrespective of cognitive load and training paradigm. Furthermore, after adjusting for state anxiety levels, cognitive load and training interacted with emotional distraction. At the physiological level, the effects of executive training were observed exclusively for negative arousing distracters, for which executive training reduced pupillary responses. Importantly, sustained effects of training were observed in Experiment 2; training reversed the association between behavioral and physiological responses and depression and anxiety levels. Together, the findings of the present study have important implications for emotion regulation and treatment of mental disorders by demonstrating the modulation of emotional distraction and mood-related behavioral and physiological responses by single-session non-emotional executive control training.

Keywords: executive control training, emotional distraction, cognitive load, pupil dilation, mental disorders

ÖZ

YÖNETİCİ KONTROL ALIŞTIRMASININ ÇATIŞMA ÇÖZÜMLEME SIRASINDA EMOSYONEL DİKKAT DAĞILIMINA ETKİSİ: GÖZ BEBEĞİ ÇAPI ÖLÇÜM ÇALIŞMASI

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Görevle ilgisi olmayan duygu bir yandan yönetsel işlemede dikkati dağıtırken, diğer yandan yönetsel kontrol duygusal işlemeyi bastırır. Bu karşılıklı biliş-duygu bağlantısı, zihinsel sağlık için kritik öneme sahip olan duygu regülasyonunun temelini oluşturur. Mevcut tez, duygu içermeyen yönetsel kontrol alıştırması kullanarak ve duygudurum ile ilgili etkileri dikkate alarak, bilişsel yük ve duygusal dikkat dağıtma arasındaki karmaşık ilişkiyi araştırmıştır. İki katılımcı grubundan biri, bilişsel yükü fazla olan bir uyuşmazlık çözümleme görevi konusunda eğitilmiş, diğeri ise bilişsel yükü az olan basit tanımlama görevini tamamlamıştır. Daha sonra her iki grup orta bilişsel yüke sahip uyuşmazlık çözümleme görevini, dikkat dağıtıcı duygusal uyaranlar varken (Deney 1) ve yokken (Deney 2) tamamlamıştır. Dikkat dağıtıcı resimler, olumluluk ve heyecanlılık boyutları dikkate alınarak seçilmiştir. Alıştırma seansı ve sonraki deneyler sırasında, katılımcıların cevapları, reaksiyon süreleri ve göz bebeği çapı kaydedilmiştir. Davranış düzeyinde, Deney 1'in sonuçları, bilişsel yük ve alıştırma paradigmasından bağımsız olarak, görevle ilgili olmayan tüm duygusal resimlerin varlığında performans düşüşünü ortaya çıkarmıştır. Ayrıca, durumluk kaygı düzeyleri ayarlandıktan sonra, bilişsel yük ve alıştırma, duygusal dikkat dağıtımı ile etkileşim göstermiştir. Fizyolojik düzeyde, yönetsel alıştırmanın etkileri, yalnızca olumsuz ve heyecan içeren resimler için gözlenmiştir; yönetsel alıştırma bu kategoride göz bebeği yanıtlarını küçültmüştür. Önemli olarak, Deney 2'de alıştırmanın sürdürülebilir etkileri gözlemlenmiştir; alıştırma, davranışsal ve fizyolojik tepkiler ile depresyon ve süreklilik kaygı düzeyleri arasındaki ilişkiyi tersine çevirmiştir. Bu çalışmanın bulguları, tek seanslık duygu içermeyen yönetsel kontrol alıştırması kullanarak duygusal dikkat dağıtma ve duygudurumla bağlantılı davranışsal ve fizyolojik yanıtların modülasyonunu göstermesi açısından, duygu regülasyonu ve zihinsel bozuklukların tedavisi için önemli çıkarımlara sahiptir.

Anahtar Sözcükler: yönetici kontrol alıştırması, duygusal dikkat dağıtma, bilişsel yük, göz bebeği büyümesi, zihinsel bozukluklar

To Hakkı, my husband and best friend.

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LIST OF ABBREVIATIONS

ABM	Attention Bias Modification
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BDI	Beck Depression Inventory
BOLD	Blood-Oxygen-Level-Dependent
dACC	Dorsal Anterior Cingulate Cortex
DLPFC	Dorsolateral Prefrontal Cortex
ECT	Executive Control Training
EEG	Electroencephalography
ERP	Event-Related Potentials
fMRI	Functional Magnetic Resonance Imaging
IAPS	International Affective Picture System
PANAS	Positive and Negative Affect Schedule
PD	Pupil Dilation
PC	Personal Computer
RMSE	Root Mean Square Error
RT	Reaction Time
S-ANX	State Anxiety Subscale
SE	Standard Error
SPSS	Statistical Package for the Social Sciences
SSIM	Structural Similarity Index Measure
STAI	State and Trait Anxiety Inventory
T-ANX	Trait Anxiety Subscale
VLPFC	Ventrolateral Prefrontal Cortex
WM	Working Memory

CHAPTER 1

INTRODUCTION

We are surrounded by a huge amount of information that cannot be simultaneously processed due to capacity constraints, as stated by William James more than a century ago (James, 1890). To deal with this complexity, attention mechanisms work in a way that prioritizes processing of information which is relevant to our goals (Broadbent, 1958). Particularly, goal-directed behavior is achieved by executive function (Banich, 2009), which includes a control system for selecting and manipulating relevant information and inhibiting irrelevant or conflicting information so that behavior can be flexibly adjusted according to goals. However, when salient stimuli interfere with current goals, inhibition of such stimuli becomes more difficult. One particular source of interference is emotional information, which has an inherent saliency and importance for survival (LeDoux, 2000), therefore higher levels of possibility to distract ongoing processes (Ambron & Foroni, 2015; Attar & Müller, 2012; Okon-Singer, Tzelgov, & Henik, 2007). A well-known effect exemplifying this situation is a fast perceptual effect of emotional distracters, namely Emotional Attentional Blink, which stands for the temporary inability to detect an upcoming target after the presentation of an emotional stimulus that is unrelated to the task (Keefe, Sy, Tong, & Zald, 2019; McHugo, Olatunji, & Zald, 2013).

Emotional distraction is a common phenomenon in daily life. You can imagine that while studying in the library, focusing on the book and ignoring others' whispering is somewhat easier than ignoring an equally intense giggling. In the morning, while you are planning your day on the bus, it is easier to ignore two people having a loud conversation than to ignore them having an argument or a baby crying. While you are hungry and driving, an attractive billboard with a large hamburger image would be more likely to jeopardize your safety than one with a cosmetic product. These everyday situations exemplify the case that irrelevant stimuli with emotional value would have a greater likelihood to automatically capture attention and distract whatever we're doing compared to emotionally neutral stimuli (see Carretie, 2014 for a review). In order to attain our goals, we need to deal with irrelevant stimuli, which appears to be difficult when distracters are emotional.

Experimentally, the influence of task-irrelevant emotional stimuli on executive function has been comprehensively studied. When emotional distracters were presented within experimental paradigms, they interfered with ongoing cognitive tasks and impaired behavioral performance to a greater extent compared to neutral distracters (e.g. Blair et al., 2007; Hodsoll, Viding, & Lavie, 2011; Kalanthroff, Cohen, & Henik, 2013; Mitchell et al., 2008; Padmala, Bauer, & Pessoa, 2011;

Müller, Andersen, & Keil, 2008; Rebetez, Rochat, Billieux, Gay, & Van der Linden, 2015; Schimmack, 2005; Verbruggen & De Houwer, 2007; see Table 2.1 for a summary of research findings for executive tasks combined with emotional distracters). The impairment resulting from emotional distraction can be explained in terms of shared resources within the framework of dual competition model (Pessoa, 2009, 2013). Basically, the idea behind this account is that task-irrelevant arousing emotional stimuli occupy executive control resources so that remaining resources become inadequate for the processing of a concurrent cognitive task (Pessoa, 2017, p.399). In line with this view, research findings indicated delayed response times in cognitive tasks in the presence of task-irrelevant emotional stimuli (i.e. emotional distraction) only for cognitively demanding conditions (Gu, Liu, Van Dam, Hof, & Fan, 2013; Hart, Green, Casp, & Belger, 2010; Jasinska, Yasuda, Rhodes, Wang, & Polk, 2012; Melcher et al., 2011). More specifically, it was shown that negative emotional distracters deteriorated behavioral performance in high-load conditions, which included conflicting response tendencies in Stroop-like tasks (Hart et al., 2010; Jasinska et al., 2012; Melcher et al., 2011) or more difficult judgments (Gu et al., 2013). For low-load conditions, which had a single response tendency or easier judgments, utilization of resources by emotional stimuli did not affect cognitive performance, since less demanding situations required less effortful control. This explanation was supported by neuroimaging results; compared to neutral task-irrelevant pictures, negative pictures combined with cognitively demanding conditions induced greater activity in frontal and parietal brain areas, which are responsible for executive processing, so that compensating the impairing effect of emotion (e.g. Gu et al., 2013; Melcher et al., 2011; Wessa, Heissler, Schönfelder, & Kanske, 2013).

Contrary to the aforementioned findings on the impairing effect of emotional distraction, other studies have found that task-irrelevant emotional stimuli or stimulus dimension may improve performance on a variety of cognitive tasks such as conflict resolution (Birk, Dennis, Shin, & Urry, 2011; Kanske & Kotz, 2011). The authors interpreted these findings as facilitated cognitive control by emotional information. This explanation was supported by subsequent experiments (Zinchenko, Kanske, Obermeier, Schröger, & Kotz, 2015). These findings confirmed the attentional breadth view stating that negative emotional stimulation narrows attention (Gable & Harmon-Jones, 2010; van Steenbergen, Band, & Hommel, 2011), which would lead to augmented processing of task-relevant information and reduced distraction by task-irrelevant information. Attentional narrowing is also in line with the automatic attentional capture by negative information (Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004).

Besides the role of affective stimuli in triggering bottom-up emotional processing (Bannerman, Milders, de Gelder, & Sahraie, 2009; Mendez-Bertolo et al., 2016), emotional responses can be generated (Ochsner et al., 2009) and more importantly modulated (Delgado, Nearing, LeDoux, & Phelps, 2008; Kim et al., 2004) by top-down processing. While emotion disturbs executive processing on the one hand

(Mueller, 2011), executive control suppresses emotional processing on the other (Dixon, 2015; Ochsner & Gross, 2005). This influence inspires an extensive research on cognitive modulation of emotional processing. The role of executive control in modulating emotional effect was supported by a line of research indicating that cognitively demanding conditions did not allow distraction by emotional information. For instance, using effortful tasks such as response inhibition (Kalanthroff, Cohen, & Henik, 2013) and conflict resolution (Cohen, Henik, & Mor, 2011), emotional distraction was found to be eliminated by recruitment of executive control. Another study manipulating cognitive task load in an embedded arrow direction task reported that preceding fearful compared to neutral faces were associated with slower response times in low-load condition (i.e. emotional distraction), faster response times in intermediate-load condition (i.e. emotional facilitation), and comparable response times in high-load condition (i.e. absence of emotional influence) (Papazacharias et al., 2015).

One possible explanation for the resistance to emotional distraction under demanding conditions can be the load theory of attention (Lavie, 1995). According to the load account, low task demands would spare attentional capacity for the processing of task-irrelevant information so that distraction occurs; conversely, high task demands would consume the attentional resources so that task-irrelevant information can be neglected (Lavie & Dalton, 2014). However, attentional load theory predicted reduced emotional distraction when the perceptual load of the task was high; when the cognitive load was high, emotional interference was elevated (Lavie, 2005; Lavie, Hirst, Fockert, & Viding, 2004). Therefore, diminished interference by emotional distracters with increased levels of executive control demands remains unexplained within this framework.

Alternatively, resistance to emotional distraction in high cognitive load can be explained by down-regulation of emotional response by executive control through inhibitory connections from prefrontal to limbic brain areas (Banks, Eddy, Angstadt, Nathan, & Phan, 2007). Supporting this proposal, neuroimaging studies reported enhanced prefrontal and suppressed limbic activity in response to emotional distracters during high-load conditions (Blair et al., 2007; Pessoa, Padmala, Morland, 2005; Van Dillen, Heslenfeld, & Koole, 2009). In addition to be associated with the reduction of emotional distraction, the prefrontal cortex is involved in emotion regulation by down-regulating limbic activity (Dixon, Thiruchselvam, Todd, & Christoff, 2017; Ochsner, Silvers, & Buhle, 2012). Emotion regulation can be considered as an effortful process that rely on executive control mechanisms (Hendricks & Buchanan, 2016; Sperduti et al., 2017; Suri, Sheppes, & Gross, 2013; Zelazo & Cunningham, 2007). Cohen and Mor (2018) recently demonstrated that activating executive control via conflict resolution not only reduced emotional distraction by task-irrelevant negative pictures but also enhanced the tendency to use and the success of reappraisal, i.e. the ability to reevaluate the meaning of an emotional stimulus/state so as to decrease the levels of negative experience.

The well-established impact of executive control on emotion regulation is closely related to mental disorders, such as depression and anxiety. These disorders have been characterized by deficits in executive control (LeMoult & Gotlib, 2019; Paulus, 2015; West, Choi, & Travers, 2010). Recently, there has been a growing interest in executive control training (ECT), given the role of executive control in both adaptive (Botvinick & Braver, 2015) and maladaptive (Paulus, 2015; Van den Bergh, Hoorelbeke, Raedt, & Koster, 2018) behavior. Building on the concept of neuroplasticity (Clark, Lawlor-Savage, & Goghari, 2017; Iacoviello & Charney, 2015; Keshavan, Vinogradov, Rumsey, Sherrill, & Wagner, 2014), training tasks target the frontoparietal network (Alvarez & Iacoviello, 2015), which is implicated in executive control function (Miller, 2000; Niendam et al., 2012; Vincent, Kahn, Snyder, Raichle, Buckner, 2008).

The training tasks used in literature can be classified into two broad categories: emotional and non-emotional (see Table 2.2 for a summary of research findings for emotional and non-emotional training paradigms with healthy samples and samples with emotional vulnerability or disorders). Emotional executive training uses emotion-laden stimuli and is primarily focused on improving selective processing of these stimuli. These training paradigms include methods such as cognitive bias modification, which aims at changing maladaptive thinking styles specific to mental disorders (Hertel & Mathews, 2011; Kuckertz & Amir, 2017), attention bias modification, which aims at normalizing attentional allocation towards negative stimuli (Mogg, Waters, & Bradley, 2017), and emotional working memory training, which aims at inducing greater control over emotional stimuli (Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013).

Non-emotional executive training tasks do not comprise emotional stimuli and target cognitive enhancement. Typical paradigms administered to healthy participants were shown to improve a broad range of executive functions including conflict resolution (Millner, Jaroszewski, Chamarthi, & Pizzagalli, 2012), attentional allocation (Aben, Iseni, Van den Bussche, & Verguts, 2019) and working memory (Klingberg, 2010; Parsons et al., 2016). Along with targeting cognitive functions, non-emotional training have also been associated with improvements in emotion regulation (Xiu, Zhou, & Jiang, 2016) and reductions in negative emotionality (Takeuchi et al., 2014), tendency to ruminate (Hoorelbeke, Koster, Demeyer, Loeys, & Vanderhasselt, 2016), and intrusive thoughts (Bomyea & Amir, 2011).

Similarly to the reported line of training research on healthy samples, emotional and non-emotional training paradigms used with depressed groups revealed promising results on symptom reduction (Calkins, McMorran, Siegle, & Otto, 2014; Nejati, Fathi, Shahidi, & Salehinejad, 2019; Siegle, Ghinassi, & Thase, 2007), executive functioning (Elgamal, McKinnon, Ramakrishnan, Joffe, & MacQueen, 2007) intellectual performance (Alvarez, Sotres, Leon, Estrella, & Sosa, 2008), verbal memory (Bowie et al., 2013; Elgamal et al., 2007; Naismith, Redoblado-Hodge, Lewis, Scott, & Hickie, 2010), and interpretation (Nejati et al., 2019). Beneficial training outcomes were also reported for anxious groups (du Toit et al., 2020; Eldar

& Bar-Haim, 2010; Sari, Koster, Pourtois, & Derakshan, 2016; Taylor et al., 2014). However, contrary to the massive number of studies regarding the effectiveness of emotional ECT in anxiety, non-emotional ECT effects remain understudied in anxiety domain. Emerging evidence of a general impairment in top-down attentional control in anxiety (Basten et al., 2011; Bishop, 2009) necessitates empirical work to reveal the influence of non-emotional training paradigms on anxiety.

Although considerable evidence has supported the efficiency of non-emotional executive control training in improving cognitive and emotional functioning, there have also been negative results showing that non-emotional ECT did not affect emotional reactivity or attentional bias to emotional stimuli as compared to training with a visual detection task (Calkins et al., 2011). Moreover, previous studies reported contradictory findings regarding the effect of non-emotional training on emotional behavior. While some studies reported positive emotional outcomes following non-emotional training (Calkins et al., 2014; Hoorelbeke et al., 2016; Nejati et al., 2019; Peckham & Johnson, 2018; Siegle et al., 2007; Takeuchi et al., 2014), other studies indicated that improving control over emotional stimuli can only be achieved by executive training with emotional stimuli (Schweizer, Hampshire, & Dalgleish, 2011). In addition to the controversy in effectiveness and transfer of executive training (Noack, Lövden, & Schmiedek, 2014; Shipstead, Redick, & Engle, 2012; Simons et al., 2016; Sprenger et al., 2013; Tidwell, Dougherty, Chrabaszcz, Thomas, & Mendoza, 2014), the underlying mechanisms of the training effect have not been well understood (Keshavan et al., 2014; Kim et al., 2018).

Training can enhance emotion regulation at multiple stages of processing. Considering the process model of emotion regulation (see Section 2.3 and Figure 2.3), training research mostly accumulates at the attentional and cognitive change levels (see Cohen & Ochsner, 2018 for a review). At the cognitive change level, emotion regulation ability can be improved by emotional executive training, which involves active manipulation of emotional stimuli by using reappraisal strategies, Denny, Inhoff, Zerubavel, Davachi, & Ochsner, 2015) or neurofeedback paradigms (Herwig et al., 2019; Zotev, Mayeli, Misaki, & Bodurka, 2020). Non-emotional training, which involves inhibition (Beauchamp, Kahn, & Berkman, 2016) and working memory (Xiu, Wu, Chang, & Zhou, 2018) tasks have also been associated with positive outcomes at this level. At the attentional level of emotion regulation, emotional executive training tasks mostly rely on attention bias modification, but have been associated with debatable attentional benefits aside from symptom reduction (Mogoaşe, David, & Koster, 2014). Non-emotional executive training has been far less studied at this level (but see Cohen et al., 2016). Since training modulates the processes that are outputs of the trained mechanism (Aben et al., 2019; Dahlin, Neely, Larsson, Backman, & Nyberg, 2008), studying the effects of non-emotional executive control training on emotional distraction would contribute to reveal attentional mechanisms underlying emotional processing. The implications of such research on mental disorders would be of great importance in terms of both theoretical and clinical purposes.

1.1. The Present Study

The present study was designed to investigate behavioral and physiological correlates of the interaction between cognitive load and emotional distraction, taking mood-related effects into account. Whether high demands in the main cognitive task lower or raise the attentional guard against task-irrelevant emotion was of primary interest. I focused on the role of non-emotional training in dealing with task-irrelevant emotional stimuli that varied along the valence and arousal dimensions. The following research questions were considered:

- Do task-irrelevant neutral and emotional information impair, improve or not affect cognitive task performance?
- What is the influence of emotional dimensions, i.e. valence and arousal, on distracting cognitive task performance?
- How does cognitive load, i.e. exertion of executive control, affect the processing of task-irrelevant emotional/neutral stimuli?
- What role does non-emotional executive control training have in emotional distraction and conflict resolution?
- How depression and anxiety states are related to conflict resolution and emotional distraction?
- How does non-emotional executive control training modulate anxiety- and depression-related effects on conflict resolution and emotional distraction?

To answer these questions, response to conflict and nonconflict situations (Experiment 2) in the presence of emotional and neutral task-irrelevant pictures (Experiment 1) was studied with or without training executive control mechanisms. Participants were randomly assigned to one of two training groups. One group (i.e. the trained group) performed a single-session modified Eriksen flanker task (Eriksen & Eriksen, 1974), in which a high proportion (70%) of trials was incongruent. The flanker task has been commonly used to generate conflict via incongruent cases and trigger executive control mechanisms to resolve the conflict (Botvinick et al., 2001; Cohen & Henik, 2012; MacLeod et al., 2010). Increasing the proportion of incongruent trials was demonstrated to increase task demands and recruitment of exeutive control (Mitchell, 2010). The other group (i.e. the untrained group) performed a simple identification version of same task, which included only congruent trials. Therefore training did not include conflict and did not require executive control for the untrained group. During the training, the untrained group was asked to indicate the pointing side of the middle arrow (up or down straightly) in an array of five arrows. For the trained group, the task was to indicate the opposite direction to the pointing side of the middle arrow (up or down reversely), in order to further increase the cognitive load.

Two subsequent experiments intended to evaluate emotional distraction and mood-related effects for these training groups during conflict resolution. Following the training session, two experiments were conducted using the same procedures for both groups. In Experiment 1, the flanker task (with arrows pointing right or left) was combined with neutral or emotional distracters, i.e. background pictures. The task-irrelevant pictures were selected from the International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 1999, 2001, 2008), according to valence and arousal ratings. The flanker task in the first experiment consisted of 50% incongruent trials. Using this task enabled the author to evaluate the effect of both training and triggering executive control on emotional distraction. In Experiment 2, the flanker task was repeated without the pictures in order to assess the effect of training on conflict resolution in the absence of distracters.

The current work takes into account the effect of emotional dimensions, which were resulted from a multi-dimensional approach to emotion classification (Scherer, Shuman, Fontaine, & Soriano, 2013) and widely accepted as valence and arousal (i.e. *pleasure* and *activation*, Barrett & Russell, 1999), on emotional distraction. Previous studies investigating emotional distraction of cognitive task performance commonly compared neutral stimuli comprising low arousal with negative stimuli comprising high arousal (Cohen et al., 2011, 2012, 2015, 2016; Dolcos & McCarty, 2006; Hart et al., 2010; Hodsoll et al., 2011; Kalanthroff et al., 2013; Melcher et al., 2011; Padmala et al., 2011). Such methodology makes the resulting effects to be attributable to negative valence, high arousal, or both. When negative and positive stimuli were used as distracters and compared to neutral distracters, the effects could still be attributed to either arousal or valence, since some studies selected negative stimuli to be significantly more arousing than positive stimuli (Mitchell et al., 2008; Müller et al., 2008; Nikolla, Edgar, Catherwood, & Matthews, 2018; Wessa et al., 2013). A study manipulating both emotional dimensions found that compared to neutral and positive distracters, arousing negative distracters impaired performance, whereas negative distracters with low arousal improved performance on a simple dot-color identification task (Sussman, Heller, Miller, & Moahnty, 2013). A more recent study showed that while arousing negative pictures impaired performance, arousing positive pictures improved performance on a video monitoring task (Nikolla et al., 2018). On the other hand, a stop-signal study demonstrated that high levels of arousal were associated with impaired task performance irrespective of valence (Verbruggen & De Houwer, 2007). A review on the effect of emotional distraction on cognitive control stated that while task-irrelevant negative information consistently disturbed cognitive control, the effect of task-irrelevant positive information was equivocal (Mueller, 2011). Concerning the effect of cognitive control on reducing emotional distraction, it was indicated that the interfering effect of both negative and positive highly arousing task-irrelevant pictures was attenuated through recruitment of cognitive control (Straub, Kiesel, & Dignath, 2020). As the reported findings suggested, the role of emotional dimensions in the interaction between emotional distraction and cognitive control is yet to be clarified. In the present study (Experiment 1), task-irrelevant pictures were broadly categorized as emotional and neutral, and emotional pictures were further classified into positive high arousal, positive low arousal, negative high arousal, and negative low arousal, based on normative valence and arousal ratings.

The present study crucially examined the relationship between the behavioral and physiological response patterns and anxiety or depression states of the participants. Specifically, the aim was to observe mood-related modulation of conflict resolution and emotional distraction by training. Some influential theories of anxiety (Eysenck, Derakshan, Santos, & Calvo, 2007) and depression (Disner, Beevers, Haigh, & Beck, 2011) focus on executive control deficits to explain emotional biases specific to these mental disorders. Engaging executive control, which refers to focusing attention in accordance with task goals so that discarding irrelevant information, is the key to deal with emotional distraction. Therefore, decreased ability to control access of task-irrelevant emotional information to attention accounts for increased proneness to distraction in these mental disorders (Joorman & Vanderlind, 2014; Morgenroth et al., 2019). The frontoparietal control network is the brain's hub for executive control (Dixon et al., 2018) and has been consistently shown to be dysfunctional in mental disorders (Cole, Repovs, & Anticevic, 2014). Therefore, training this network could improve executive control thereby reduce emotional distraction, so that providing a plausible way to remedy the disruptions in anxiety and depression.

1.2. Predictions and Hypotheses

It is predicted that recruitment of executive control will reduce emotional distraction in terms of both behavioral performance and pupillary response. Moreover, executive control training might modulate mood-related effects on these measures. The specific hypotheses for all phases of the present study are as follows:

For the Training session:

H1. Performance scores are expected to be better in congruent compared to incongruent trials for the trained group.

H2. Pupil dilation is expected to be increased in incongruent compared to congruent trials for the trained group, due to increased mental effort induced by conflicting stimuli.

For Experiment 1:

H3. Impaired conflict resolution performance in the presence of highly arousing distracters compared to neutral ones is expected for the untrained group.

H4. Augmentation of behavioral interference effect in the presence of highly arousing emotional distracters is expected for the untrained group.

H5. Anxiety and depression levels are expected to be negatively associated with performance scores for the untrained group in demanding conditions; this pattern is predicted to be disappeared or reversed for the trained group.

H6. Reduced conflict adaptation effect is expected for the untrained group in the presence of arousing emotional distracters.

H7. Pupil dilation is expected to increase in response to arousing negative and positive distracters for the untrained group compared to the trained group.

H8. Augmentation of pupillary interference effect in the presence of arousing emotional distracters is expected for the untrained group.

For Experiment 2:

H9. A behavioral interference effect is expected for both groups, although larger for the untrained group compared to the trained group.

H10. A physiological interference effect is expected for both groups, although larger for the untrained group compared to the trained group.

H11. Anxiety and depression levels are expected to be negatively associated with performance scores for the untrained group; this pattern is predicted to be disappeared or reversed for the trained group.

CHAPTER 2

BACKGROUND

2.1. Emotional Distraction of Executive Processing

Executive processing, which includes generating and updating goals, manipulating relevant information, and inhibiting conflicting or irrelevant information, enables an organism to behave flexibly and adaptively. Task-irrelevant information distracts attention and interferes with the maintenance of task-relevant information. When the task-irrelevant information has emotional content, the likelihood of distraction is greater (Ellis & Ashbrook, 1988). This is not surprising when the effect of emotion on sensation is considered. There is a large body of evidence showing that emotional stimuli evokes greater neural activity compared to neutral stimuli in sensory processing areas in the brain such as visual (Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005; Vuilleumier, Armony, Driver, & Dolan, 2001), auditory (Grandjean et al., 2005), and gustatory (O'Doherty, Rolls, Francis, Bowtell, & McGlone, 2001) cortices. Furthermore, compared to neutral content, emotional information, either positive or negative, elicits greater activation in the sympathetic system as measured by pupillary and skin conductance responses (Bradley, Miccoli, Escrig, & Lang, 2008). In addition to enhancing sensory and autonomic processing, emotional information competes for attention. This is considered to be necessary from the evolutionary perspective; emotional stimuli have higher value in terms of survival (LeDoux, 1996), so they have an attentional advantage (Pourtois, Schettino, & Vuilleumier, 2013).

The influence of emotion on anatomically separable attention networks (Fan, McCandliss, Fossela, Flombaum, & Posner, 2005), namely orienting, alerting, and executive function (Posner & Peterson, 1990; see Peterson & Posner, 2012 for extensions of the framework) has been demonstrated using various tasks.

One example for the orienting network was a spatial cueing paradigm (Okon-Singer et al., 2007). Participants initially saw three squares, with a fixation cross in the middle square. This was followed by a 100ms flash of the right/left square as a cue, and the target (the letter Q or O) appeared on the cued or the opposite side. Simultaneously with the target, an emotional or neutral picture was presented in the other square. The task was to ignore the image and discriminate whether the letter was a Q or an O. When the cue was invalid so the distracter was presented in the cued position, reaction times were slower in the negative distracter trials compared to neutral distracter trials. In valid trials, there was no difference between negative and neutral distracters. The authors concluded that emotional interference occurs when the emotional stimuli appears in the attentional focus.

Concerning the emotional influence on the alerting network, when negative emotional stimuli (i.e. fearful faces) were presented as inter-stimulus distracters, alertness decreased for the following trial (Dennis, Chen, & McCandliss, 2008). In particular, when a fearful face was presented before a cue for the subsequent target, the enhancing effect of the cue was reduced compared to a neutral face. However, when emotional stimuli were presented as targets to be evaluated, electrophysiological responses at trial onset were facilitated compared to neutral stimuli (Schupp et al., 2004).

While disruption of the third attentional system, executive processing, by task-irrelevant emotional information is demonstrated in many experimental paradigms, there are also contradictory findings (see Table 2.1 for a summary of research findings for executive tasks combined with emotional distracters). There is a large body of evidence indicating that when emotional stimuli are presented as distracters, they interfere with the current cognitive tasks and impair performance to a greater extent compared to emotionally neutral distracters. Interruption of executive processing was demonstrated in a study (Schimmack, 2005), where emotional and neutral distracter pictures were presented during a mathematical calculation task (determining which of the two products, e.g. 3 x 5 or 2 x 8, were larger) or a simple visual detection task (determining whether a line appeared on the top or at the bottom of the screen). It was found that arousing negative and positive emotional pictures led to slowest reaction times in both tasks. Another study showed that emotional pictures presented before and after target stimuli also impaired performance on a simple visual detection task (Mitchell et al., 2008). Blair and colleagues (2007) showed that response times delayed for both congruent and incongruent trials in a numerical Stroop task when combined with task-irrelevant negative and positive pictures compared to neutral pictures. Hodsoll, Viding, and Lavie (2011) showed the deteriorating effect of irrelevant emotional information by employing a search task, in which participants indicated the orientation of a target face among distracter faces. When the distracters included an emotional expression, reaction times were delayed compared to when the target expressed an emotion or both the target and distracters were neutral. Another study used a face-word Stroop task (Padmala, Bauer, & Pessoa, 2011), in which male or female faces were presented with written words on them congruently (e.g. a female face with the written word *female* on it) or incongruently (e.g. a male face with the written word *female* on it). The face-word Stroop stimuli were followed by neutral or negative images. When a neutral image was presented between trials, interference effect was reduced for trials preceded by incongruent stimulus, so there was a conflict adaptation effect (preparing control mechanisms after an incongruent trial so that better managing the upcoming conflict). Negative images led to a significant reduction of conflict adaptation increasing the interference effect after incongruent trials. Besides emotional stimuli inserted in cognitive tasks, there is also evidence showing that induced emotional states (i.e. mood) impaired performance on subsequent reasoning tasks such as Wason's selection task and Tower of London task (Oaksford, Grainger, Morris, & Williams, 1996).

Table 2.1. Summary of Research Findings on Emotional Distraction Paradigms (↑: increased; ↓: decreased; RT: reaction time; ct.: compared to)

Distracter Type	Distracter Presentation	Executive Task	Behavioral Performance	Executive Function (As Indexed by Behavior)	Reference
Pictures	Prior to and In-Between Targets	Numarical Stroop Task	↑ RT for negative and positive ct. neutral pictures	Impaired	Blair et al., 2007
Faces	Prior to Target	Delayed Response Working Memory Task	↓ Correct responses for negative ct. neutral	Impaired	Dolcos & McCarthy, 2006
Pictures	Simultaneous	Body Part Judgment (Hand/Foot) Laterality Judgment (Right/Left)	↑ RT in painful ct. non-painful stimuli in laterality judgement task	Impaired	Gu et al., 2013
Pictures	Prior to Target	Number-Stroop Task	↑ RT in incongruent trials for negative ct. neutral	Impaired	Hart et al., 2010
Faces	Simultaneous	Gender-based Search Task	↑ RT when distracters included emotional expression	Impaired	Hodsoll et al., 2011
Pictures	Prior to Target	Stop Signal Task	↑ Stop-signal RTs for negative ct. neutral pictures	Impaired	Kalanthroff et al., 2013
Pictures	Prior to Target	Stroop Task	↑ Error rates in incongruent trials for negative ct. neutral	Impaired	Melcher et al., 2011
Pictures	Prior to and Following Target	Simple Visual Detection Task	↑ RT for negative and positive ct. neutral pictures	Impaired	Mitchell et al., 2008
Pictures	Simultaneous	Target Detection Task	↓ Target detection rates for negative and positive ct. neutral pictures	Impaired	Müller et al., 2008
Pictures	Inter-Trial	Face-Word Stroop Task	↓ Conflict adaptation after negative ct. neutral	Impaired	Padmala et al., 2011
Faces	Simultaneous	Stop Signal Task	↑ Stopping latencies for angry and happy ct. neutral expressions	Impaired	Rebetez et al., 2015
Words	Prior to Target	Recent Negative Task	↑ RT and error rates for positive words ct. negative and neutral words		

Table 2.1. (cont.)

Distracter Type	**Distracter Presentation**	**Executive Task**	**Behavioral Performance**	**Executive Function (As Indexed by Behavior)**	**Reference**
Pictures	Simultaneous	Mathematical Calculation and Simple Visual Detection Tasks	↑ RT for negative and positive ct. neutral pictures in both tasks	Impaired	Schimmack, 2005
Pictures	Prior to Target	Stop Signal Task	↑ Response and stopping latencies for positive and negative ct. neutral images (Exp. 1) ↑ Stop-signal RT for high-arousal ct. low arousal images (Exp. 2)	Impaired	Verbruggen & De Houwer, 2007
Pictures	Simultaneous	Aritmetic Task	↑ RT for emotional ct. neutral distracters ≈ Error rates in negative and neutral	Impaired	Wessa et al., 2013
Faces	Prior to Target	Arrow Flanker Task	↓ Conflict effect after fearful faces in anxiety-induced group ct. neutral mood-induced group	Improved	Birk et al., 2011
Words	Simultaneous	Color Flanker Task	↓ RT for negative words in incongruent trials	Improved	Kanske & Kotz, 2011
Words, Pictures	Prior to Target	Recency-Probes Interference Paradigm	↓ Interference following emotional ct. neutral stimuli	Improved	Levens & Phelps, 2008
Faces	Simultaneous	Face Contrast Discrimination Task	↓ Thresholds for face contrast discrimination for the group trained using emotional faces ct. the group trained using facial identity and untrained group	Improved	Lorenzino & Caudek, 2015
Faces	Prior to Target	Orientation Discrimination Task	↓ Levels of contrast needed to discriminate orientation of Gabor patches in fearful ct. neutral condition	Improved	Phelps et al., 2006

Table 2.1. (cont.)

Distracter Type	**Distracter Presentation**	**Executive Task**	**Behavioral Performance**	**Executive Function (As Indexed by Behavior)**	**Reference**
Faces & Voices	Simultaneous	Voice Detection Task	↓ Conflict effect when faces and voices were emotional ct. neutral	Improved	Zinchenko et al., 2015
Faces	Simultaneous	Orientation Discrimination Task	≈ RT in fearful and neutral condition	No effect	Pessoa et al., 2005
Pictures	Simultaneous	Line Orientation Identification Task	≈ RT in negative, positive and neutral conditions	No effect	Straube et al., 2008

Although there is a line of research supporting the impairing effect of emotion on executive processing, there is also evidence showing that irrelevant emotional stimuli enhance executive function. One such study employed a modified version of the Attention Network Test after inducing anxious or happy mood to two groups of participants (Birk, Dennis, Shin, & Urry, 2011). They found in the anxiety-induced group that fearful faces presented prior to flanker arrow stimuli were associated with a smaller conflict effect compared to neutral faces, thus facilitating conflict resolution performance. In another study using the Color Flanker task (Kanske & Kotz, 2011), participants were asked to determine the ink color of a target word, which was either neutral or negative. The same word printed below and above each target congruently (with the same ink color) or incongruently (with a different ink color). According to reaction time results, there was no difference between negative and neutral stimuli in congruent trials. However, incongruent trials were responded faster when the word was negative compared to when it was neutral, yielding a facilitated conflict resolution in the emotional (i.e. negative) condition. Subsequent experiments showed that while determining whether the pronounced vowel was "A" or "O", visual-auditory mismatch revealed a smaller conflict effect when faces and voices were emotional compared to when they are neutral, despite emotional dimension was irrelevant to the task (Experiment 1 in Zinchenko, Kanske, Obermeier, Schröger, & Kotz, 2015). Other studies showed that preceding fearful faces facilitated perceptual discrimination of the orientation of Gabor patches compared to neutral faces (Phelps, Ling, & Carrasco, 2006) and that training participants with emotional changes in faces improved face contrast discrimination performance compared to training them with identity changes or not training (Lorenzino & Caudek, 2015). In response inhibition tasks, there are also contradictory findings demonstrating that emotional compared to neutral content impairs (Kalanthroff, Cohen, & Henik, 2013; Rebetez et al., 2015; Verbruggen & De

Houwer, 2007) or improves (Levens & Phelps, 2008) the capacity to inhibit a dominant response.

The effect of task-irrelevant emotional information on separate attentional networks (i.e. orienting, alerting, and executive function) might be modulated by factors such as distracter emotion type, task difficulty and stimulus duration. In an Emotional Attention Network Test (O'Toole, DeCicco, Hong, & Dennis, 2011), target stimuli were presented briefly (100ms) in the difficult condition and until a response was given in the easy condition. When there was a lower task demand, orienting and alerting was enhanced by angry and fearful face distracters compared to happy faces. But this effect in orienting and alerting disappeared in the higher task demand condition. On the other hand, for executive processing, when the distracters were presented for longer durations impairment was greater compared to shorter durations. Similarly, it was stated that whether emotion impairs or improves executive processing may depend on the methods used for data analysis (Cohen & Henik, 2012). Therefore, Cohen and Henik (2012) suggested that the emotional influence should be examined on congruent and incongruent cases separately rather than calculating a conflict score (RT in incongruent trials - RT in congruent trials) and comparing the effect of neutral and emotional distracters on this score.

Aforementioned research has shown the modulatory role of emotion in attention. In order to study the role of attention in emotional processing, Wiens, Sand, Norberg, and Andersson (2011) manipulated the relevancy of emotional and neutral pictures to the experimental task in an ERP paradigm. In the experiment, participants saw pictures surrounded by letters (two letters below and above, one letter to the right and left sides of each picture were displayed). In one block, they were asked to decide whether the picture was the same as or different from the previous picture. In another block, they were asked to decide whether the letter N was shown. The results revealed that when the pictures were attended to, early posterior negativity (EPN) was smaller and late positive potential (LPP) was greater for negative pictures than for neutral pictures. However, when the letters were attended to, although the pictures were still in the center, the difference between negative and positive pictures disappeared in EPN and substantially diminished for LPP. The authors noted that although picture emotionality was not the attended dimension in both tasks, attention towards or away from pictures influenced the processing of emotional information (Wiens et al., 2011). Similarly, in a location detection task (Lichtenstein-Vidne, Henik, & Safadi, 2012), when neutral pictures were the targets (shown below or above fixation cross) and emotional pictures were distracters (shown at the opposite location to the target), behavioral performance was not influenced by distracter valence. In a second experiment, when both the target and distracter pictures had emotional content, performance decreased for the trials with negative distracters. Although emotionality of pictures was task-irrelevant for both experiments, it interfered with performance when the target included emotional information. Both studies have implications on automaticity of emotional processing, suggesting that emotional information is processed automatically if the stimuli in the attentional focus comprises emotional information, even though this information is irrelevant to the experimental task.

2.2. Theoretical Accounts on Emotional Distraction

Theoretical accounts on emotional and cognitive processing mostly rely on neuroscience research. In the mid-twentieth century, MacLean (1952) developed the limbic system theory, explaining how emotion is processed in the brain. Since then, the notion of limbic system solely dedicated to emotion and neocortex solely dedicated to cognition has been challenged (Nakano, 1998; Okon-Singer, Hendler, Pessoa, & Shackman, 2015). Recent accounts focus on the integration of emotion and cognition at multiple levels of processing to guide behavior (Pessoa, 2008). However, the intensified processing of emotional information, which makes it more difficult to suppress, is still considered to result from bottom-up neural signals mediated by amygdala (Vuilleumier, 2005).

The neural substrates of emotional distraction were investigated in several neuroimaging studies and behavioral manifestations of interference were explained in terms of the dissociation between cortical and subcortical pathways in the brain. These two systems work in opposite directions. That is, dorsal executive brain regions, such as Dorsolateral Prefrontal Cortex (DLPFC) and dorsal Anterior Cingulate Cortex (dACC), increase activity in response to attention-demanding tasks and decrease activity during emotional processing, whereas ventral emotional brain regions such as amygdala exhibits the reverse activation patterns (Drevets & Raichle, 1998). Emotional distraction of executive function is suggested to be mediated by the interplay between these systems. For example, Dolcos and McCarthy (2006) employed a delayed-response working memory task with emotional (i.e. negative) and nonemotional (i.e. neutral and scrambled) distracters. Participants first saw a set of three faces, then were presented distracter pictures during the 6-second delay period, and then decided whether the probe face was present in the initial set. It was found that behavioral performance was impaired to a greater extent when the distracters had negative emotional content compared to neutral and scrambled distracters. Along with this behavioral effect, activation in brain areas such as DLPFC, which were active during delay period with non-emotional images, was suppressed during emotional images. In other words, behavioral impairment on working memory task was accompanied by diminished activity in cognitive control areas (primarily DLPFC) during presentation of task-irrelevant emotional pictures. Dolcos and McCarthy (2006) also found that negative emotional distracters triggered activity in limbic areas such as amygdala. These findings relate impaired cognitive performance in the presence of negative emotional information to the activation of ventral brain systems and simultaneous deactivation of dorsal systems during emotional distraction. This antagonistic relationship between the two neural systems is thought to underlie behavioral impairment by irrelevant emotional information (see Iordan, Dolcos, & Dolcos, 2013 for a review).

This pattern was replicated in another fMRI study (Anticevic, Repovs, & Barch, 2010) also employing a delayed response WM task. Anticevic et al. (2010) additionally showed that during negative, but not neutral, distracters, a greater prefrontal deactivation was observed for incorrect trials compared to correct trials. In consistent with this, increased activity in these areas was associated with successful resilience to negative distraction. On the other hand, amygdala activity was negatively correlated with WM performance. Moreover, the negative correlation between amygdala activity and prefrontal activity was stronger during negative distracters than neutral distracters and resting state. Therefore, emotional disruption of working memory maintenance sheds light on how cognitive (prefrontal) and affective (limbic) brain systems interact and impair goal-directed behavior. Dolcos, Iordan, and Dolcos (2011) refer the executive system as "ColdEx" and the affective system as "HotEmo". The reciprocal influence between these networks was illustrated in Figure 2.1. According to this model, maintenance of task-relevant information in WM is mediated by Dorsal Executive (ColdEx, shown in blue) system, including structures such as the DLPFC. Emotional processing is mediated by Ventral Effective (HotEmo, shown in red) system, including structures such as the Amygdala. When task-irrelevant information has emotional content, increased activity in HotEmo system along with decreased activity in ColdEx system underpins the behavioral impairments. Supporting this view, inter-stimulus emotional distracters eliminated behavioral adjustment after incongruent trials in a conflict resolution task (Padmala et al., 2011). This was interpreted as utilization of working memory resources by negative task-irrelevant information so that the representation of the encountered conflict was not maintained to create conflict adaptation.

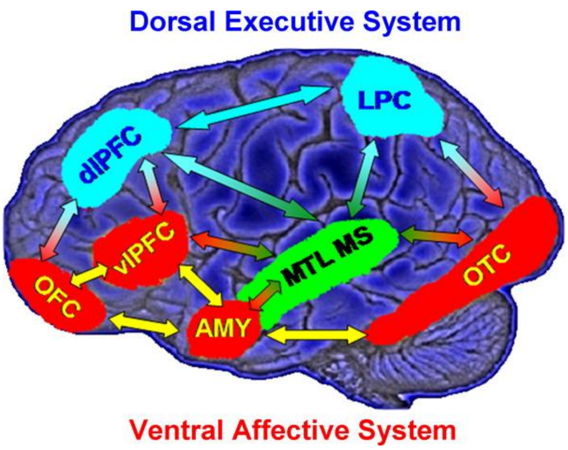


Figure 2.1. Neural Underpinnings of Disrupted WM Maintenance and Impaired Performance in the Presence of Emotional Distracters (Dolcos, Iordan, & Dolcos, 2011, p.676)

The neuropsychological model explains the distraction of working memory maintenance by irrelevant emotional information. The relationship between processing of irrelevant emotional information and immediate attention, however, is less agreed upon. Contradictory findings imply amygdala reponse was (Krolak-Salmon, Henaff, Vighetto, Bertrand, & Mauguiere, 2004; Pessoa, McKenna, Gutierez, & Ungerleider, 2002) or was not (Anderson, Christoff, Panits, De Rosa, & Gabrieli, 2003; Vuilleumier et al., 2001) modulated by attention. The amount of attention to emotional stimuli may explain these contradictory findings. Lavie (1995)'s attentional load theory suggests that when the perceptual load of a cognitive task is low, attentional capacity allows for processing of task-irrelevant information. Depending on this account, Pessoa, Padmala and Morland (2005) manipulated attentional load of a main cognitive task in the presence of emotional distracters. The participants were asked to report whether the orientation of two bars was the same, each presented in the right and left side of an emotional (fearful) or a neutral face. The angular difference between the two bars was manipulated so as to create three difficulty levels, each of which was administered in a separate block. Results showed that amygdala response to fearful faces was greater than the neutral faces only for the easy condition. For intermediate and difficult conditions, there were no significant activity differences in amygdala between fearful and neutral distracters. Greater amygdala activity in response to fearful compared to neutral faces was more prominent in the gender detection task, which comprised the same stimuli but the task was to identify the gender of faces, so the emotional information was attended. Moreover, when only the bar orientation task was employed at the difficult level without the distracters, baseline amygdala response was suppressed. These findings support the idea of attentional modulation of limbic response, as stated in mutually suppressive emotional and cognitive networks account (Drevets & Raichle, 1998).

Theoretical models of emotional distraction of executive operations suggest different underlying mechanisms for emotion-cognition links. According to the dual competition model (Pessoa, 2009, 2013), emotional distracters impair behavioral performance on an ongoing cognitive task, because they occupy certain resources needed for the cognitive task (see Figure 2.2). This model assumes that emotional and cognitive processes share resources. Studies that reported emotional interference, i.e. delayed response times in the presence of emotional distracters, only for cognitively demanding conditions are in line with this view. For instance, an fMRI experiment was conducted using the Stroop task with negative and neutral pictures preceding the target stimuli (Melcher et al., 2011). They found larger error rates in incongruent trials when negative distracters were presented compared to neutral distracters. The neural correlates of Stroop interference were also designated by greater activation in prefrontal cortex and additional activations in parietal and extrastriate visual areas in negative emotional condition compared to neutral condition, indicating a higher degree of top-down attentional control for cognitive interference (created by incongruent trials) in order to resist emotional interference (created by negative pictures). In a number Stroop task (Hart, Green, Casp, & Belger, 2010), in which the number of items presented in an array is congruent (e.g. 333) or incongruent (e.g. 444) with the written digits, preceding negative pictures delayed responses compared to neutral pictures, but only in incongruent trials. Hart et al. (2010) also reported decreased activity in Ventrolateral Prefrontal Cortex (VLPFC) and Insula in response to aversive pictures compared to neutral pictures, but only in congruent trials. The authors concluded that when the executive task demands were low, emotional distracters suppress activity in a ventral prefrontal network; however, high task demands counteracted the attenuation effect.

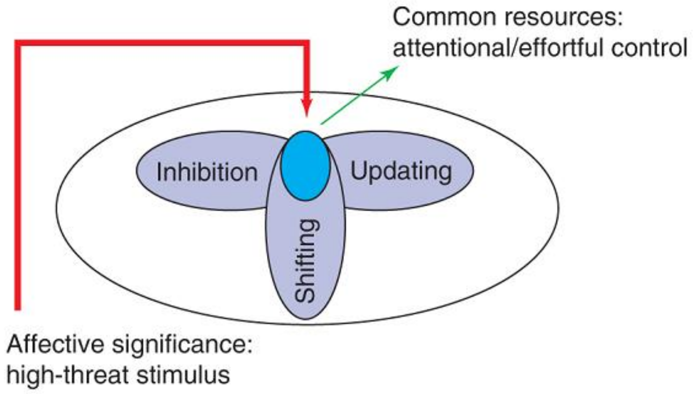


Figure 2.2. Dual Competition Model (Pessoa, 2009). Emotional distracters occupy processing resources for prioritization, so that impair executive functions (Inhibition, Updating, and Shifting) that share these resources.

In contrast to the integrative approach of dual competition framework, other models are built on modular processing and independence of emotional and non-emotional processing (Egner, 2008). This view was supported by neural activation patterns in response to emotional and non-emotional interference. For instance, when participants identified the gender of affective face stimuli and there is a conflicting word, its resolution was mediated by lateral prefrontal involvement and enhanced sensory cortex activation for task-relevant stimuli (Egner, Etkin, Gale, & Hirsch, 2008). However, when they identified affective expression of the faces and there is a conflicting word, its resolution was mediated by rostral anterior cingulate involvement and suppressed amygdala activation for distracters (Egner et al., 2008). Similarly, in a word flanker task (Ochsner, Hughes, Robertson, Cooper, & Gabrieli, 2009), when the task was to determine whether a target word was positive or negative (surrounded by congruent or incongruent words), rostral medial prefrontal cortex was activated. When the task was to determine whether the target word was metal or fruit, vetrolateral prefrontal cortex was activated. Moreover, these differential activations were positively correlated with response latencies in the corresponding tasks. It is worth to note that both studies (Egner et al., 2008; Ochsner et al., 2009) in favor of modular conflict resolution account also reported common neural sites that were recruited during both emotional and non-emotional types of conflict, suggesting an additional common mechanism for conflict resolution.

2.3. Cognitive Modulation of Emotion

Affective inputs not only elicit bottom-up processing by orienting attention (Bannerman et al., 2009; Ohman, Flykt, & Esteves, 2001), but also are shaped by top-down processing. How an individual interprets an emotional stimulus determines the processing of that stimulus. For instance, Kim and colleagues (2004) presented surprised faces in an fMRI setting and asked participants to passively view them. These faces were preceded by positive sentences, such as "She just found $500", and equivalent negative sentences such as "She just lost 500$". While emotional stimuli with negative context activated ventrolateral PFC, positive context resulted in ventromedial PFC activity in response to emotional faces. In addition, when identical surprised expressions were preceded by negative context, they induced greater amygdala activation compared to positive context condition. Therefore, emotional response is modulated by contexual information. Cognitive components of the task can also modulate emotional processing. This hypothesis was confirmed by changing the task demands on the same emotional stimuli. In a functional MRI study (Hariri, Bookheimer, & Mazziotta, 2000), when participants matched faces according to emotional expressions, amygdala response was increased. However, neural response in amygdala was decreased when the same faces were matched with emotional labels. In addition, prefrontal cortex activity increased for the face-label matching task, suggesting involvement of top-down processing. A similar pattern was observed in another PET study (Taylor, Phan, Decker, & Liberzon, 2003), in which participants either passively viewed or rated pleasantness of emotional pictures. While passive viewing increased amygdala activity, emotional rating decreased amygdala activation and revealed additional activity in prefrontal cortex.

In the domain of emotional distraction, the influence of cognitive load has been increasingly studied (e.g. Sebastian, McCrory, De Brito & Viding, 2017). Behaviorally, cognitive modulation of emotional distraction has been investigated in studies combining executive tasks with task-irrelevant emotional information. For instance, Cohen, Henik, and Mor (2011) displayed neutral or negative pictures cueing the location of the subsequent arrow flanker stimuli. The most pronounced finding of this study was that while preceding negative pictures impaired performance (delayed reaction times) for congruent trials, they did not affect performance on incongruent trials. Furthermore, emotional distraction was reduced for trials that were preceded by incongruent stimuli. The authors stated that the results support the involvement of a top-down control mechanism, which was triggered to resolve the conflict and inhibit emotional distraction. In follow-up studies, this effect was replicated and possible underlying mechanisms were investigated. In the first experiment, it was indicated that when there is a conflict to resolve (induced by incongruent condition in the arrow flanker task), the effect of preceding irrelevant emotional information, which was stronger in congruent trials, was suppressed (Cohen, Henik, & Moyal, 2012). Moreover, this effect was observed for the group of participants who reported frequent use of cognitive techniques, not for the group who scored low on the use of cognitive techniques. In the second experiment, neutral and negative images were preceded by congruent and incongruent flanker stimuli and followed by a simple discrimination task. Performance on the discrimination task was better when the emotional pictures were preceded by conflict situations. Together, these findings support the inhibitory effect of cognitive control on emotional distraction.

Neuroimaging research on inhibition of emotional processing through executive control emphasizes prefrontal suppression of the limbic system. Van Dillen et al. (2009) designed an emotional distraction task and measured fMRI BOLD activity. They presented a negative or a neutral picture before a simple (e.g. 7+2=9) or a complex (2*8+12=28) equation, which participants determined whether true or false. At the end of each trial, participants also rated their mood based on unpleasantness (1: not unpleasant at all; 8: very much unpleasant). Results showed increased limbic (amygdala and insula) activation in response to negative compared to neutral pictures. In the complex equation trials, while activation in cortical areas (DLPFC, superior parietal, dorsal occipital) was enhanced, activation in limbic areas was reduced along with ratings of unpleasantness. Similar results to the emotional priming studies, in which distracters preceded target stimuli, were obtained when emotional and neutral distracters were presented simultaneously with arithmetic problems (Wessa et al., 2013). Wessa et al. (2013) reported enhanced prefrontal and task-specific activity in response to negative compared to neutral pictures. The authors interpreted this activity combined with comparable error rates in both negative and neutral conditions as compensatory to achieve similar levels of behavioral performance under emotional distraction. Based on such research, neurobiological emotion regulation models focus on exertion of executive control through inhibitory connections from cortical (mainly prefrontal) pathways to the limbic system (mainly amygdala) (Banks et al., 2007; Ochsner et al., 2012).

Whether emotional distraction is modulated by cognitive load depends on the mode (i.e. implicit and explicit forms) of emotional processing. This was demonstrated in a behavioral study, in which emotional distracters preceding target stimuli were explicitly evaluated, passively viewed, or evaluated based on non-emotional features (Cohen, Moyal, Lichtenstein-Vidne, & Henik, 2016). When emotional pictures were passively viewed or explicitly aveluated based on emotional content, high cognitive load prevented emotional distraction. However, when emotional processing was implicit (i.e. pictures were evaluated based on non-emotional content) both high and low cognitive load conditions were distracted by emotional information.

Emotional response can be up-regulated or down-regulated through top-down mechanisms at different steps of processing (Gross, 1998) so the emotional experience can be more or less intense. For instance, conditioned fear response was found to be attenuated both physiologically and neurally by using emotion regulation strategies (Delgado, Nearing, LeDoux, & Phelps, 2008). A widely studied emotion regulation strategy, cognitive reappraisal, involves reinterpretation of the meaning of an emotional event by such as generating an alternative scenario (Gross, 2002). For example, when someone was disturbed by an image of a badly injured person in a movie can reappraise thinking that the injuries were formed by make-up. Such tendencies can be trained (Jackson, Malmstadt, Larson, & Davidson, 2000) and were suggested to modulate stimulus processing at early processing stages, contrary to suppression of emotional response (Ochsner, Bunge, Gross, & Gabrieli, 2002).

Research on emotion regulation has been integrated into theoretical frameworks. One of the most respected conceptualizations has been the Process Model of Emotion Regulation (Gross, 1998; Gross & Thompson, 2007). As shown in Figure 2.3, the model differentiates five points of processing where emotion regulation may occur. The level to which emotion can be cognitively modulated was hypothesized to be on a continuum ranging from attentional control to cognitive change (Ochsner & Gross, 2005). Response-focused emotion regulation strategies are employed in order to suppress emotional experience after an emotional response was already generated. In contrast, antecedent-focused emotion regulation strategies are employed so that emotional response can be modulated. People may avoid or alter situations, which previously elicited a certain emotional response (Gross & Thompson, 2007, p.6). Attentional deployment includes orientation of attention toward emotional or nonemotional stimulus properties and cognitive chance includes altering the interpretation of certain emotional stimulus (Webb, Miles, & Sheeran, 2012).

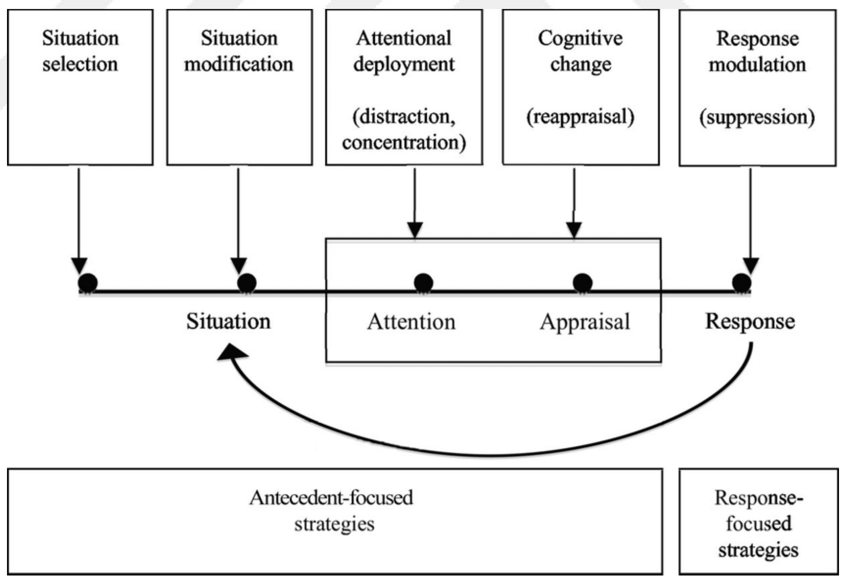


Figure 2.3. The Process Model of Emotion Regulation (Webb, Miles, & Sheeran, 2012, p.776 adapted from Gross & Thompson, 2007, p.10)

Another well-known model of emotion regulation focuses on neural underpinnings of these processes and takes into account whether emotion regulation is voluntary or automatic (Phillips, Ladouceur, & Drevets, 2008). The authors suggested that both voluntary and automatic regulatory processes take place in three main domains including behavioral, attentional, and cognitive levels. At behavioral level, while automatic regulation involves inhibition of conditioned affective responses

(Rosenkranz, Moore, & Grace, 2003), voluntary regulation involves suppression of emotional expressions (Gross & Levenson, 1997). At attentional level, automatic control of emotion has been exemplified in dot-probe tasks, where a target appears at the same location as a previous emotional stimulus yields faster response times compared to targets preceded by emotional distracters at the opposite location (Pourtois, Schwartz, Seghier, Lazeyras, & Vuilleumier, 2006). The voluntary counterpart of attentional control has been commonly studied in emotional Go/NoGo tasks, in which a preponent emotional response, such as reading a word printed in italics, is inhibited (Goldstein et al., 2007). Lastly, at cognitive level, voluntary control typically includes reappraisal strategies (Phan et al., 2005), whereas automatic cognitive change includes implicit risk learning in gambling tasks (Ernst et al., 2002). As Phillips et al. (2008)'s neural model in Figure 2.4 depicts, the role of prefrontal circuits were emphasized in all forms of emotion regulation. While medial prefrontal areas were implicated in automatic mode of emotion regulation through feedforward connections, lateral prefrontal areas were implicated in voluntary mode of emotional regulation.

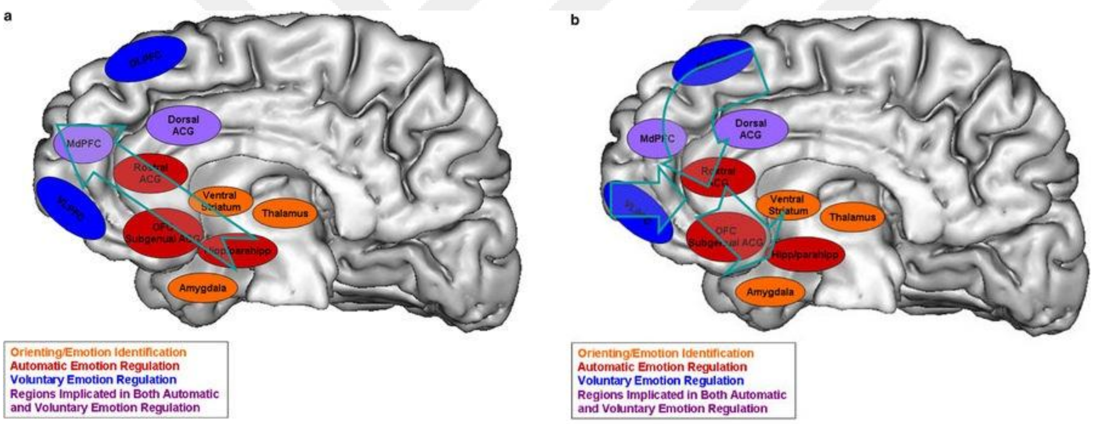


Figure 2.4. Neural Models for Automatic and Voluntary Emotion Regulation (Phillips, Ladouceur, & Drevets, 2008, p.31)

a. Automatic emotion regulation by feedforwad connections from medial prefrontal areas

b. Voluntary emotion regulation by feedback connections from lateral prefrontal areas

Regions and their functions are color-coded.

2.4. Altered Cognitive and Emotional Processing in Anxiety

In terms of detection of and response to danger, biological mechanism of fear has an undeniable survival value (Cannon, 1929). However, this adaptive fight-or-flight response to immediate threats differs from anxiety, which includes worrying about future or potential threats (Grillon, 2008). Such maladaptive tendencies influence cognitive functioning (Robinson, Vytal, Comwell, & Grillon, 2013).

As detailed in the next section, mood-congruent information processing has been repeatedly supported in memory domain but controversial in attention domain for depression. The opposite of this pattern was observed for anxiety; mood-congruent bias has been agreed upon in attention domain but less clear in memory domain (Williams, Watts, MacLeod, & Mathews, 1997). For example, in an early study employing the dot-probe task (MacLeod, Mathews, & Tata, 1986), emotional and neutral words were presented simultaneously and briefly in the upper or lower part of the screen, followed by the target probe at one of these locations. While participants with high anxiety responded faster to the probes at the location of emotional (threat-related) words, low anxiety group was faster at the location of the neutral words, managing to disengage from threat-related stimuli. There is also evidence showing that high levels of anxiety was not associated with initial orientation to threat, but instead with difficulty in disengaging attention away from such stimuli (Salemink, van den Hout, & Kindt, 2007).

Earlier attempts to cognitive modeling of selective processing in anxiety focus on competing representations (Mathews & Macintosh, 1998). As shown in Figure 2.5, neutral target and emotional distracter compete for attention. This is also applicable to different attributes of the same stimulus, such as in the case of modified Stroop tasks, in which word color and meaning of emotional word compete for attention. In either case, representation of the target needs to be facilitated and representation of the distracter needs to be inhibited for goal-directed response according to task demands. The empirically supported Threat Evaluation System stands for automatic processing of emotional significance of the input. Higher levels of anxiety leads to greater extents of threat representations (due to learning) and lower thresholds for the outputs of this system, therefore facilitating distracter processing, which in turn hinders target processing in the absence of other contributory mechanisms. Another empirically supported system in the model is top-down control exerted by task demands, which stands for voluntary effort and improves the representation of a certain target or attribute, which in turn inhibit distracter processing. According to this model, emotional interference depends on the extent of automatic threat processing on the distracter and voluntary task processing on the target.

A later account, attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007), is largely in line with this cognitive model, with additional emphasis on the influence of anxiety on central executive functions, namely inhibition and shifting. Within the scope of attentional control theory, anxiety impairs processing efficiency, which was distinguished from performance effectiveness. Bottom-up/stimulus-driven and top-down/goal-directed attentional systems were also differentiated. Eysenck and colleagues (2007) mainly stated that anxiety reduces the effect of top-down control in addition to enhancing the effect of bottom-up processing. This approach also includes increased processing of threat-related inputs but mainly focuses on decreased goal-directed inhibitory functioning in anxiety.

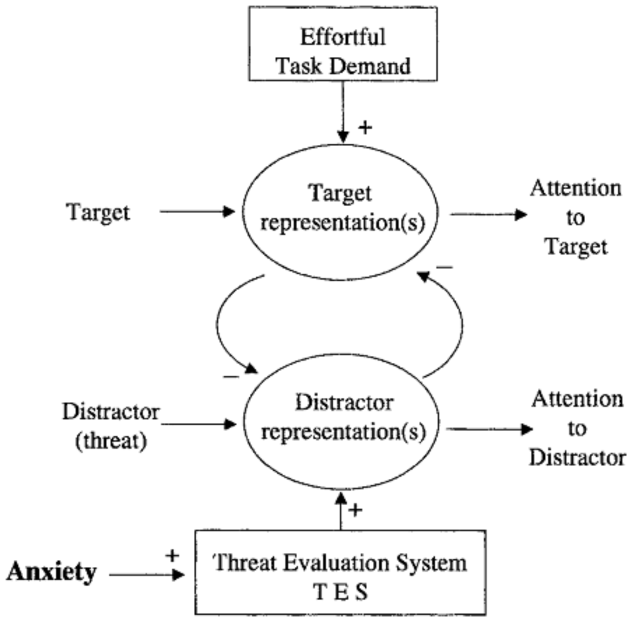


Figure 2.5. Cognitive Model of Selective Processing in Anxiety (Mathews & Macintosh, 1998)

There has been considerable evidence showing attentional bias toward threatening stimuli in individuals with anxiety disorders or high levels of trait anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Bishop, Duncan, Brett, & Lawrence, 2004; Morrison & Heimberg, 2013; Yiend & Mathews, 2001). High levels of state anxiety were also indicated to increase amygdala response to fearful versus neutral faces, regardless of faces being ignored or attended (Bishop, Duncan, & Lawrence, 2004). Despite the strong association between anxiety and attentional bias to threat in literature, it was also proposed that rather than an attentional tendency specific to threat, anxiety may induce a more general impairment in top-down attentional control. This hypothesis was supported in a number of experimental paradigms. Bishop (2009) employed a flanker task and found that under lower levels of task demand participants with high trait anxiety showed greater conflict interference, i.e. slower response times, and diminished prefrontal activation. Although there were no threat-related distracters, attentional control was impaired for high levels of trait anxiety and low levels of attentional demands (Bishop, 2009). Similarly, a classical color-word Stroop task was used in an fMRI setting in order to test whether anxiety more broadly impairs attentional control (Basten, Stelzel, & Fiebach, 2011). The authors demonstrated that participants with high trait anxiety showed greater interference effect, i.e. higher error rates in incongruent versus congruent trials, compared to participants with low trait anxiety. In addition, DLPFC activity in response to incongruent versus congruent trials was greater in high-anxious group compared to low-anxious group. This result was interpreted as greater but less efficient neural effort and was linked to inhibitory control deficits associated with irrelevant competing stimulus properties.

More recently, Morgenroth et al. (2019) administered the color-word Stroop task during fMRI in low and high trait anxiety groups in addition to H-MRS (proton magnetic resonance spectroscopy). Similarly to Basten et al. (2011), they observed greater but less efficient DLPFC activity in high trait anxiety group; despite greater prefrontal activaiton levels, they performed worse than the low trait anxiety group on the Stroop task, which was characterized by higher error rates in incongruent trials. Moreover, DLPFC activity and prefrontal glutomate levels were positively correlated only for the low trait anxiety group during incongruent trials. These results suggest that the relationship between neurochemistry and neural activity may underlie anxiety-related deficits in cognitive control.

2.5. Altered Cognitive and Emotional Processing in Depression

Since ancient Greek medicine, depression has been recognized as a severe mental disorder (see Horwitz, Wakefield, & Lorenzo-Luaces, 2016 for a historical review). After Aaron Beck (1987) proposed the cognitive model of depression, research on cognitive mechanisms (Ingram, 1984; Mathews & MacLeod, 2005; Teasdale, 1988) and more recently neural mechanisms of this disorder (Disner et al., 2011) has been advanced.

There is considerable evidence suggesting that depressed participants perform poorly on executive tasks (see Snyder, 2013 for a meta-analysis) and neuropsychological tests (see Rock, Roiser, Riedel, & Blackwell, 2014 for a meta-analysis). Cognitive dysfunction in depression was reported in studies using various cognitive tasks (e.g. Channon & Green, 1999; Cohen, Weingartner, Smallberg, Pickar, & Murphy 1982; Marazziti et al., 2010). The dysfunction is characterized by comparing performance of depressed and healthy groups in a variety of domains such as visuospatial learning and memory (Porter, Gallagher, Thompson, & Young, 2003), selective attention along with working memory, verbal long-term memory, and verbal fluency (Harvey et al., 2004; Landro, Stiles, & Sletvold, 2001; Levens & Gotlib, 2010). The malfunction is suggested to be mediated by cognitive impairments specific to depression (Austin, Mitchell, & Goodwin, 2001; McIntyre et al., 2013). Moreover, impaired cognition was found to be predictive of developing depression in healthy individuals (Pe, Brose, Gotlib, & Kuppens, 2016; Zetsche & Joormann, 2011) and persistently observed after remission (Hasselbalch, Knorr, & Kessing, 2011).

Along with performance deficits, neural abnormalities in depression were found predominantly within the prefrontal regions, especially the DLPFC. However, the results are mixed in terms of the direction of change; while some studies reported increased activation in task-positive areas (Fitzgerald et al., 2008; Harvey et al., 2005; Matsuo et al., 2007; Schöning et al., 2009; Walter et al., 2007), others reported decreased activation in similar areas (Nixon et al., 2013; Okada et al., 2009; Siegle et al., 2007) for depressed groups relative to healthy controls. One explanation for the discrepancy is the use of medication such that an unmedicated depressed sample showed under-activity in this area during an emotional interference task (Fales et al., 2008). The hypoactivation in DLPFC observed in depressive participants during cognitive tasks with emotional interference was indicated to be normalized after SSRI antidepressant treatment (Fales et al., 2009). Increased activation in the task-positive network in depressed groups compared to healthy samples and equivalent performance between the two groups is commonly interpreted as greater recruitment of brain areas in depressed patients to achieve similar levels of behavioral performance to healthy controls (Fitzgerald et al., 2008; Harvey et al., 2005; Matsuo et al., 2007). Supporting this interpretation, increased DLPFC activation in correct trials (Walter, Wolf, Spitzer, & Vasic, 2007) and Cingulate Cortex hyperactivation (Schöning et al., 2009) were postulated as "compensatory" in depression.

In addition to impaired executive processing, depressive population is more prone to emotional distraction. This was demonstrated in a modified color-word Stroop task (Segal, Gemar, Truchon, Guirguis, & Horowitz, 1995), in which depressed and control participants named the ink color of positive and negative adjectives. Emotional phrases priming the adjectives were also rated by the participants to what degree they describe themselves. It was found that depressed group named the ink color slower when the adjectives were negative and self-descriptive compared to positive adjectives. Reaction times in the control group did not differ between negative and positive adjectives; neither there was an influence of self-descriptiveness. Self-reference to negative schemas results in impairments in memory, attention, and interpretation, therefore forming the basis for dysfunctional cognition in depression (Clark, Beck, & Alford, 1999). Flexible behavior is achieved through inhibition of irrelevant information to access WM to control behavior. This was illustrated in negative affective priming (NAP) studies, in which a previously irrelevant item becomes relevant in the subsequent trial and leads to longer response latencies as a result of successful inhibition (Tipper, 2001). Depressive participants, however, failed to demonstrate this effect for negative distracters (faces), which were the subsequent targets (Goeleven, Raedt, Baert, & Koster, 2006). An fMRI procedure employing the NAP task found abnormalities in the rostral Anterior Cingulate Cortex (rACC) in depressed participants during the inhibition of negative words (Eugene, Joormann, Cooney, Atlas, & Gotlib, 2010). Emotional go-nogo tasks were also employed to show that depression is associated with reduced response inhibition to negative information, i.e. sad faces (Yu et al., 2017).

Theoretical models (see Figure 2.6) characterize depression as a combination of cognitive biases and insufficient cognitive control (Joormann & Vanderlind, 2014). Mood-congruent information processing account asserts that information processing is biased toward negatively-valenced materials for negative mood (Bower, 1981). Biased processing of emotional information plays an important role on the onset and maintenance of depressive disorder (Beck, 1987). It is worth to note that depressed individuals did not differ in their initial response to negative material or even responded less intensely (Rottenberg, 2007). However, the main difficulty in depression was suggested to be the inability to disengage from negative material (Joormann, 2004). While the mood-congruent bias is well-established in memory (Bradley & Mathews, 1983; Clark & Teasdale, 1982; Dalgleish & Watts, 1990;

Gilboa-Schechtman, Erhard-Weiss, & Jeczemien, 2002; Ridout, Astell, Reid, Glen, & O'Carroll, 2003) and interpretation domains (Mogg, Bradbury, & Bradley, 2006), studies on biased attention revealed contradictory results (Peckham, McHugh, & Otto, 2010). Therefore, some researchers included memory bias in cognitive accounts of depression and excluded attention bias from this account (Williams, Watts, MacLeod, & Mathews, 1997).

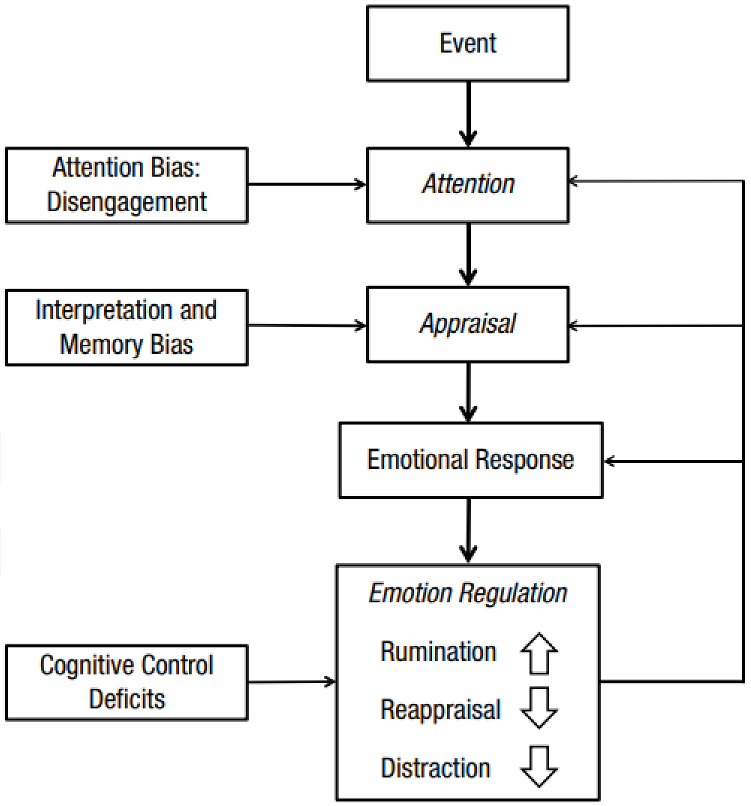


Figure 2.6. Cognitive Inhibition Model (Joormann, 2010)

Evaluation of attentional allocation in depression has been studied commonly employing emotional Stroop and Dot Probe tasks (Peckham et al., 2010). In the former task, participants are required to name the ink color of an emotional or neutral word, which is criticized to indicate attentional allocation indirectly, since response bias may underlie response latencies (Mathews & MacLeod, 2005). A more direct measure of attention allocation is the Dot Probe task, in which emotional and neutral stimuli are presented simultaneously on the same display and followed by visual probes in the corresponding locations. The idea is that greater attention to negative stimuli leads to shorter response times to probes presented in the same location (Mathews & MacLeod, 2005). In a quantitative review, studies using Dot Probe task were found to reveal significantly greater attention to negative stimuli in depressed samples compared to healthy, while studies using emotional Stroop task revealed smaller effect sizes (Peckham et al., 2010).

Cognitive models of depression also focus on biased attentional processing and its relation to emotion dysregulation (Beck, 1987). Bias toward negative material is considered to underlie the main characteristic of depression, which is sustained negative affect (Gotlib & Joormann, 2010). More recently, depressed patients' bias away from positive material was included in this account (Duque & Vazquez, 2015; Winer & Salem, 2016). Neural underpinnings of such tendencies have been investigated and altered prefrontal modulation of emotional information was reported in many studies (e.g. Bermpohl et al., 2009; Fales et al., 2009; Gotlib et al., 2005). When the stimuli incorporated emotional content, increased activation in frontal areas was regarded as attentional bias towards negative information in depression (Kerestes et al., 2012b). On the other hand, activation decrease in frontal areas in depression was termed as "hypofrontality" (Buchsbaum et al., 1986) and considered to be associated with insufficient cognitive control in depression (Matsuo et al., 2007; Okada et al., 2009; Siegle, Thompson, Carter, Steinhauer, & Thase, 2007). Higher vulnerability to emotional interference observed in depression is associated with deficient cognitive control (Joormann & Tanovic, 2015), which is manifested by decreased DLPFC activation underlying difficulties in inhibition of negative affective material (Foland-Ross & Gotlib, 2012). Evidence supporting this interpretation was reported in a transcranial direct current stimulation study, which showed that DLPFC stimulation improved depressive symptoms in addition to behavioral scores on a neuropsychological test battery (Salehinejad, Ghanavai, Rostami, & Nejati, 2017). Similarly, another transcranial direct current stimulation study found that stimulating DLPFC improves working memory performance and eliminates attentional bias in depressive sample (Wolkenstein & Plewnia, 2013).

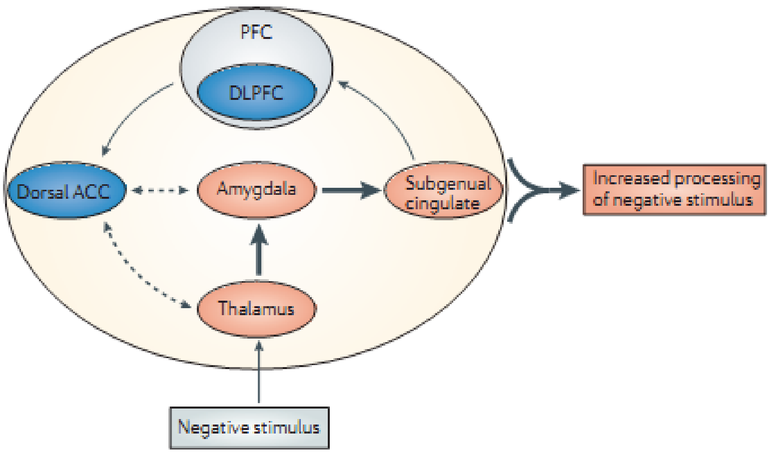


Figure 2.7. The Neurobiological Model of Depression (Disner et al., 2011)

This top-down explanation also applies to emotional disturbances observed in depression (Plewnia, Schroeder, & Wolkenstein, 2015). It was proposed that depression is related to a deficit in executive control, which is mediated by prefrontal hypoactivation (Liu et al., 2014), and this makes inhibition of emotional distraction more difficult (Fales et al., 2008). Alternatively, the neural mechanisms of the disruptive effect of emotion on executive processing in depression were hypothesized to function in a bottom-up manner (Ongür & Price, 2000), mediated by amygdala hyperactivation (Sheline et al., 2001). These two explanations were combined in Disner, Beevers, Haigh, and Beck (2011)'s neurobiological model, which was schematized in Figure 2.7. In this model, depression is characterized by the interaction between several brain areas. Limbic hyperactivity (shown in red) and concurrent prefrontal hypoactivity (shown in blue) in response to negative stimulation are associated with cognitive control deficits, which in turn inhibit dorsal anterior cingulate to regulate the emotional response and result in elevated emotional distraction.

2.6. Executive Control Training

Recently, there has been a growing interest in executive control training (ECT) as an effective approach to treatment of mental disorders (Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017; Motter et al., 2016), given the role of executive control in maladaptive behavior (Grahek, Shenhav, Musslick, Krebs, & Koster, 2019; Iordan, Dolcos, & Dolcos, 2013; Joormann & Vanderlind, 2014; Paulus, 2015; Van den Bergh, Hoorelbeke, Raedt, & Koster, 2018). Table 2.2 summarizes research findings for emotional and non-emotional ECT paradigms with healthy groups and groups with emotional vulnerability or disorders. As can be seen in the table, both emotional and non-emotional ECT have been associated with improvements in a wide range of cognitive functions (Aben et al., 2019; Millner et al., 2012; Parsons et al., 2016; Xiu et al., 2016), emotion regulation ability (Hoorelbeke et al., 2016; Schweizer et al., 2013; Xiu et al., 2016), and emotional states (Takeuchi et al., 2014) for healthy samples.

It has been repeatedly specified that cognitive impairment is a key characteristic of depression and may persist after remission or antidepressant use (Hasselbalch et al., 2011; Reppermund, Ising, Lucae, & Zihl, 2009). Therefore, interventions that solely focus on improving cognitive function were suggested for depression treatment (Trivedi & Greer, 2014). Compatibly, a brain stimulation study showed that recovery from depression consolidated when transcranial direct current stimulation was combined with non-emotional ECT (Segrave, Arnold, & Fitzgerald, 2014). Furthermore, prefrontal activity was reported to be normalized in a depressed sample after non-emotional training (Siegle et al., 2007). More recently, Schneider et al. (2019) found increased resting state activity in prefrontal cortex in depressive patients after they completed a 5-week training, which includes a wide range of cognitive functions. In addition, non-emotional training paradigms used with depressed samples revealed promising results on symptom reduction (e.g. Calkins, McMorran, Siegle, & Otto, 2014; see Motter et al., 2016 for a meta-analysis), and variable forms of executive functioning (Alvarez et al., 2008; Bowie et al., 2013; Elgamal, McKinnon, Ramakrishnan, Joffe, & MacQueen, 2007; Naismith, Redoblado-Hodge, Lewis, Scott, & Hickie, 2010).

Table 2.2. Summary of Research Findings for Emotional and Non-emotional Executive Control Training Paradigms with Healthy Samples and Samples with Emotional Vulnerability or Disorders. (N: number of participants; M.A.: mean age; EEG: electroencephalography; fMRI: functional magnetic resonance imaging; ↑: increased; ↓: decreased; RT: reaction time; ct.: compared to)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Healthy; Prime-Attended Group (N= 20, M.A.=19.4) Prime-Diverted Group (N=24, M.A.=19.2)	Single-session on Day 2 (Pre-test on Day 1 and Post-test on Day 3)	Arrow Priming Task	Attentional modulation	Direct, Close and Far Transfer Tasks	↓ Congruency effect in Prime-Diverted Group ct. Prime-Attended Group Generalization to Direct Transfer Task, but not to Close and Far Transfer Tasks	Aben et al., 2019
Healthy; Training Group (N=29, M.A.=21.6) Control Group (N=32, M.A.=21.2)	10 online sessions over two weeks	Modified Paced Auditory Serial Addition Task	Emotion regulation	Dual N-back Task, Experience Sampling Method, Visual Analogue Scale	↑ Performance for the training group on dual n-back task ct. the control group Training reduced maladaptive emotion regulation (rumination) but did not affect adaptive emotion regulation	Hoorelbeke et al., 2016
Healthy (N=20, M.A.=27)	Three sessions on Days 2, 3, and 4 (Pre-test on Day 1 and Post-test on Day 5)	Simon Task Emotional Go/No-Go Task	Interference resolution	Flanker Task, Emotional Face-Stroop Task, EEG	↓ RT in incongruent, but not congruent, flanker trials pre- to post-training ↓ N2 amplitudes in incongruent, but not congruent, flanker trials pre- to post-training	Millner at al., 2012
Healthy; Training Group (N=10, M.A.=23.5) Control Group (N=10, M.A.=23.5)	Twice a week for 5 weeks	Three-Dimensional Multiple Object Tracking Program	Attention, Working memory, Visual information processing speed	Neuropsychological Tests, EEG	↑ Scores on several subtests on cognitive measures for the training group ct. control group ↓ Delta, Theta and Alpha, ↑ Beta and Gamma band frequencies only in the training group pre- to post-training	Parsons et al., 2016

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Healthy; Cognitive Training Group (N=14; M.A.=25), Cognitive-Emotional Training Group (N=15; M.A.=25), Control Group (N=16; M.A.=25)	20 days in four five-day blocks	Neutral N-Back Task (Cognitive Training) Affective N-Back Task (Cognitive Affective Training)	Working Memory Capacity, Fluid Intelligence, Affective Executive Control	Forward Digit Span Test, Raven's Progressive Matrices, Emotional Stroop Task	↑ Performance on digit span for both training groups, not for the control group ↑ Fluid intelligence scores for both training groups, not for the control group ↑ Performance on both congruent and incongruent trials on emotional Stroop only for the cognitive-emotional training group	Schweizer et al., 2011
Healthy; (M.A.=23); Training Group (N=17) Control Group (N=15)	20 daily sessions	Emotional Dual N-Back Task	Emotion regulation	Emotion Regulation Task, fMRI	↑ Reduction in emotional distress to negative films in the training group, not in the control group ↑ Pre- to post-training activity in frontoparietal network for the training group ct. the control group	Schweizer et al., 2013
Healthy; Training Group (N=41, M.A.=20.9) Control Group (N=20, M.A.=21.4)	27 daily sessions	Visuospatial WM Task, Auditory Backward Operation Span Task, Dual WM Task, Dual N-Back Task	Emotional states	Neuropsychological Tests and Mood Questionnaires Face-Matching Task, fMRI	↓Pre- to post-training scores on anger, depression and fatique for the training group ct. control group ↓Pre- to post-training negative-emotion-related brain activity for the training group ct. control group	Takeuchi et al., 2014

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Healthy; Training Group (N=20, M.A.=21.7) Control Group (N=20, M.A.=22.6)	20 daily sessions	Running Working Memory Task	Emotion regulation	Two-back Task, Emotion Regulation Task, High-frequency Heart Rate Variability	↓ Post-training RT in 2-back task for the training group ct. the control group ↑ Post-training Heart Rate Variability during emotion regulation for the training group ct. the control group	Xiu et al., 2016
Depressed; Training Group (N=24, M.A.=35.7) Control Group (N=24, M.A.=35.8)	Three sessions within two weeks	Modified Paced Auditory Serial Addition Task, Attention Control Intervention	Symptom reduction	Beck Depression Inventory, Positive and Negative Affectivity Scale, Visual Analogue Scale	↓ Depression scores in the training group ct. control group	Calkins et al., 2014
Ruminators (Age range between 18 and 37); Inhibit Negative Training Group (N=35) Attend to Negative Training Group (N=26) Control Group (N=33)	Four sessions over two weeks	Negative Affective Priming Task	Inhibition of negative stimuli, Brooding, Symptom reduction	Negative Affective Priming Task, Beck Depression Inventory, Ruminative Responses Scale	↓ Inhibition of irrelevant negative words for the attend to negative training group pre- to post-training ↓ Rumination, but not depression, scores after training for the group trained to inhibit negative words, no difference in these scores for the other groups	Daches & Mor, 2014

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Individuals with High Social Anxiety Scores; Training Group (N=21, M.A.=22.6) Control Group (N=19, M.A.=23.4)	Six sessions on six days	Emotional Dual N-back Task	Peak anxiety levels during impromptu speech, Negatively-biased repetitive thinking, Working memory capacity	Digit Span Backwards Task, Anticipatory Processing Questionnaire, Peak Anxiety Rating Scale, Attentional Focus Questionnaire, Post-Event Processing Questionnaire	↓ Peak anxiety for the training group, not for the control group ↓ Thinking about the past for the training group, not for the control group	du Toit et al., 2020
Anxious and Non-anxious; Training Group-Anxious (N=15, M.A.=23.3) Training Group-Non-Anxious (N=15, M.A.=22.2) Control Group-Anxious (N=15, M.A.=22.1) Control Group-Non-Anxious (N=15, M.A.=23.1)	Single session (five blocks)	Modified Probe Detection Task	Top-down attentional control	Dot-probe task, EEG	↓ RT to targets following neutral faces throughout the training only for the trained anxious group ↓P2 and P3 amplitudes and ↑N2 amplitude in post-training only for the trained anxious group	Eldar & Bar-Haim, 2010

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Depressed; Training Group (N=12, M.A.=50.3) Control Group (N=12, M.A.=47.2) Healthy control (N=22, M.A.=49.1)	Two weekly sessions for ten weeks	Cognitive Remediation Software Program	Memory, Attention, Executive functioning, Psychomotor speed	California Verbal Learning Test, Ruff's 2&7 Selective Attention Test, Wechsler Adult Intelligence Scale, WAIS-R Similarities Subtest, Trail Making Test, Controlled Oral Word Association Test, Hamilton Depression Rating Scale	↑ Performance improvements on attention, verbal learning and memory, psychomotor speed and executive function for the training group ct. control groups	Elgamal et al., 2007
Depressed; Training Group (N=8, M.A.=33.4) Control Group (N=8, M.A.=33.6)	Two weekly sessions for ten weeks	Neuropsychological Educational Approach to Remediation	Neuropsychological functioning	Hamilton Depression Rating Scale, Wechsler Test of Adult Reading, Depression-Anxiety-Stress Scale, Rey Auditory Verbal Learning Test, Trail-making Test, Rey Complex Figure Test, Controlled Oral Word Association Test	↑ Pre- to post-training improvements on verbal learning and memory for the training group, not for the control group	Naismith et al., 2010
Depressed; Training Group (N=11, M.A.=20.1) Control Group (N=11, M.A.=19.6)	Ten sessions over five weeks	Interpretation and Attention Bias Modification Program	Interpretation bias, Symptom reduction	Beck Depression Inventory, Depression-Anxiety-Stress Scale, Eye-Image Mind Reading Test	↓ Depression scores in the training group, but not in the control group ↓ Biased interpretation in the training group, but not in the control group	Nejati et al., 2019

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Individuals with High Emotional Impulsivity (M.A.= 32) Training Group (N=22) Control Group (N=17)	Six sessions over two weeks	Adaptive Paced Auditory Serial Addition Task, Adaptive Go/No-Go Task	Impulsivity, Emotion regulation, Cognitive performance	Paced Auditory Serial Attention Task, Go/No-Go Task, Antisaccade Task, Digits Forward and Digits Backwards Task, Wechsler Test of Adult Reading, Feelings Trigger Action Scale, Ruminative Response Scale, Emotion Regulation Questionnaire, Mood, Anxiety, and Stress Questionnaire	↓ Emotion-related impulsivity from pre- to post-training for the training group, not for the control group ↓ Rumination and ↑ Reappraisal for the training group ↑ Performance on the non-adaptive Go/No-Go task for the training group	Peckham & Johnson, 2018
Individuals with High Trait Anxiety Scores; Training Group (N=17, M.A.=25) Control Group (N=16, M.A.=26)	Daily sessions for three weeks	Adaptive Dual N-Back Task	Attentional control	Flanker Task, Attentional Antisaccade Task, EEG	↓ Interference scores in Flanker Task pre- to post-training for the training group, not for the control group ↑ Pre- to post-training reductions in the slow wave/fast wave ratio (in resting state EEG) for the training group ct. control group No effects for the Attentional Antisaccade Task	Sari et al., 2016

Table 2.2. (cont.)

Participants	Time Interval of Training	Training Tasks	Targeted Functions	Assesment Tasks/Measures	Training Outcomes	Reference
Depressed (Age range between 18 and 55); Training Group (N=19), Control (Treatment As Usual) Group (N=10)	Six sessions over two weeks	Wells's Attention Training, Adaptive Paced Auditory Serial Addition Task	Symptom reduction	Beck Depression Inventory, Response Style's Rumination Questionnaire, Digit Sorting Task, Personal Relevance Rating, Emotion Identification, fMRI, Pupil Dilation	↓ Depression and rumination scores pre- to post-training in the training group ct. the control group ↓ Amygdala activity to negative and neutral words, ↑ Amygdala activity to positive words, ↓ Prefrontal activity to easy digit sorting, ↑ Prefrontal activity to difficult digit sorting for the training group from pre- to post-training ↓ Sustained pupil dilation during emotional assessment in both groups from pre- to post-training	Siegle et al., 2007
Individuals with High Social Anxiety Scores (N=14; M.A.=19.4)	Single session	Modified Probe Detection Task	Emotion regulation	Emotion Face Assessment Task, State Anxiety Subscale, fMRI	↓ Amygdala, Insula and Subgenual Anterior Cingulate cortex activity and ↑ Prefrontal activity in response to emotional faces for post-training ct. pre-training	Taylor et al., 2014

Anxiety has been extensively linked to threat-related attentional bias (Bar-Haim et al., 2007; Bishop et al., 2004; Morrison & Heimberg, 2013; Yiend & Mathews, 2001), thus attention-bias modification (ABM) training, which includes dot probe task design and aims at orienting attention to positive cues and away from threatening cues, has been offered as an effective treatment for anxiety (Jones & Sharpe, 2017; MacLeod & Mathews, 2012; Mogg & Bradley, 2018). In a recent randomized trial, ABM was found to be more influential in reducing anxiety symptoms compared to cognitive bias modification, control, and combined intervention conditions (Naim, Kivity, Bar-Haim, & Huppert, 2018). Although some meta-analytic studies challenged ABM's efficacy as a common practice for anxiety disorders due to smaller effect sizes compared to cognitive behavioral therapy or pharmacological treatment (Heeren, Mogoaşe, Philippot, McNally, 2015), others reported satisfactory effect sizes for ABM training in symptom reduction (Beard, Sawyer, & Hofmann, 2012; Hakamata et al., 2010). In addition to symptom reduction and behavioral improvement, fMRI studies found decreased activity in limbic areas (such as Amygdala and Subgenual ACC) and increased activity in prefrontal areas during an emotional face assessment task after anxious participants completed a single-session attention modification program (Taylor et al., 2014). An ERP study also demonstrated that ABM modulates the response patterns in top-down control areas for trained anxious sample (Eldar & Bar-Haim, 2010). As an emerging intervention for individuals with anxiety symptoms, emotional working memory training was shown to reduce peak anxiety during improvisational speech that the participants were told to be evaluated by the experimenters (du Toit et al., 2020). Similarly to the ABM training, emotional working memory training was shown to induce increased activity in prefrontal and parietal brain regions during an emotion regulation task (Schweizer et al., 2013).

As the neuroimaging studies suggested, training approaches in affective disorders rely on plasticity of the brain (Clark et al., 2017; Iacoviello & Charney, 2015; Keshavan et al., 2014). Training tasks target the frontoparietal network (brain regions such as DLPFC, dACC, and inferior parietal lobule), which is implicated in cognitive control function (Miller, 2000; Niendam et al., 2012; Vincent, Kahn, Snyder, Raichle, Buckner, 2008) and also critically in emotion regulation (Kalisch, 2009). The underlying neural mechanism of ECT effect is centered on the frontoparietal network, which was shown to be disrupted in depression and anxiety (for a meta-analysis see Pico-Perez, Radua, Steward, Menchon, & Soriano- Mas, 2017). Figure 2.8 shows a neural model of training targets in ECT for affective disorders. In the figure, neural malfunctions in affective disorders were highlighted as hyperctivity (red squares; Thalamus, Amygdala, Hippocampus, Subgenual Cingulate Cortex), hypoactivity (blue squares; Dorsal Anterior Cingulate, Dorsolateral Prefrontal Cortex, Ventrolateral Prefrontal Cortex), and weakened connectivity (dashed lines). The main objective in ECT interventions is to enhance top-down control and improve emotion regulation via strengthening these connections.

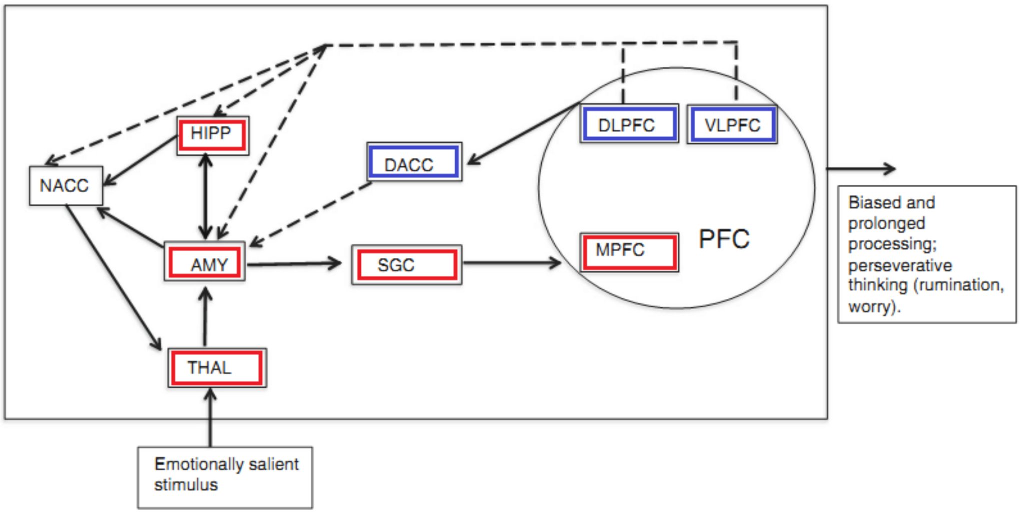


Figure 2.8. Neural Model of Targets for Executive Control Training in Affective Disorders (adapted from Alvarez & Iacoviello, 2015)

Training approaches in the field of mental disorders not only focus on depressive or anxious symptomatology, but also on risk factors and correlates of anxiety and mood disorders. As a salient example, the relationship between cognitive control and rumination (as a risk factor for affective disorders) was indicated (e.g. Joorman, 2006). Rumination can be briefly defined as repetitive thinking with negative focus and is associated with depression and anxiety as a predictive and vulnerability factor (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Recently, depression and rumination links were suggested to be reciprocal (Whisman, du Pont, Butterworth, 2020). ECT was shown to decrease the tendency to ruminate. For instance, Daches and Mor (2014) recruited participants who tend to ruminate frequently and trained them to inhibit or attend to negative information. After completing four sessions, while training attention to negative content impaired inhibition of negative distracters, training inhibition enhanced this ability and decreased rumination scores. In another study, Siegle et al. (2014) demonstrated that while symptoms were reduced equivalently after executive training and usual treatment for a depressed sample, rumination scores were reduced only after training. The efficacy of training was also demonstrated for reducing emotional impulsivity (Peckham & Johnson, 2018) and vulnerability to depression and anxiety in non-clinical samples (Beloe & Derakshan, 2019).

In training research, the degree to which the training task generalizes is critical. Improvement can be observed for the same task, for similar tasks (near transfer) and for distinct tasks (far transfer) after training (Shipstead, Redick, & Engle, 2010). Researchers have been reported that cognitive training enhances performance only in the trained cognitive task/domain, or a close cognitive domain, but not a distant cognitive domain (Enge et al., 2014; Shipstead, Redick, & Engle, 2012; Simonet, von Roten, Spierer, & Barral, 2019; Simons et al., 2016; Talanow & Ettinger, 2018). It has also been stated that training does not improve overall cognitive functioning

(Melby-Lervag, Redick, & Hulme, 2016; Sala & Gobet, 2019; Sprenger et al., 2013). Despite the controversy, meta-analytic literature provides promising evidence for its effectiveness at least for near-transfer level for healthy samples (Au et al., 2015; Klingberg, 2010) and for symptom reduction in depressed samples (Motter et al., 2016). Transfer effects of training were also showed in addition to symptom reduction for anxiety (Sari et al., 2016).

2.7. Pupil Dynamics

Pupil dilation (PD) has long been acknowledged as an indicator of general stimulation including loud tones, novelty, threat of a gunshot, (un)pleasantness of pictures, and muscle contraction (Nunnally, Knott, Duchnowski, & Parker, 1967). Early studies showed that increased emotionality (Hess & Polt, 1960; Janisse, 1974), increased memory load (Kahneman & Beatty, 1966), increased number of alternative responses (Richer & Beatty, 1987), and increased task difficulty (Kahneman & Beatty, 1967) leaded to increased pupil size. Accordingly, PD was associated with resource allocation (Ahern & Beatty, 1979; Hess & Polt, 1964).

For six decades, as a physiological measure and an index of autonomic nervous system, PD has been widely used in emotional and cognitive processing tasks. Pupil dilation was shown to be a reliable measure of emotional processing under various experimental conditions (Rosa, Esteves, & Arriaga, 2015; Snowden et al., 2016). In addition, pupillometry has been increasingly used in studies on cognitive control (for a review, see van der Wel & Steenbergen, 2018) and emotion regulation (Bebko, Franconeri, Ochsner, & Chiao, 2011; Kinner et al., 2017).

In emotional domain, covariance between pupil dilation and skin conductance response during processing of pictures with high emotional arousal, regardless of whether they were pleasant or unpleasant, suggests the involvement of sympathetic nervous system (Bradley, Miccoli, Escrig, & Lang, 2008). This pattern was later supported by the findings that natural scenes elicited greater PD when their context was emotional (pleasant and unpleasant) compared to neutral (Ferrari et al., 2016) and imagining a scene while reading its description elicited grater PD when the context of the narrative texts was emotional (pleasant and unpleasant) compared to neutral (Handerson, Bradley, & Lang, 2018). Arousing positive and negative auditory stimuli were also shown to result in greater pupil size compared to neutral auditory stimuli (Partala & Surakka, 2003). However, the theoretical account linking pupil response to emotional arousal was challenged in some studies. For instance, in a free viewing experiment, it was shown that pupils dilated more in response to angry faces/bodies and aggressive scenes compared to happy faces/bodies/scenes that were rated equally intense or neutral stimuli (Kret, Roelofs, Stekelenburg, & de Gelder, 2013). Other studies also found significantly elevated dilation in pupils in response to negative compared to positive images (Kawai, Takano, & Nakamura, 2013), faces (Laeng et al., 2013) and sounds (Babiker, Faye, & Malik, 2013).

Pupil dilation has also been measured in studies of emotional disorders. For example, in order to test mood congruent information processing hypothesis (Bower, 1981), depressed adolescents were compared to healthy controls while deciding the valence of emotional faces (Burkhouse et al., 2017). It was found that in depressed group pupils dilated more for sad, fearful and happy conditions, i.e. all emotional expressions. Similarly, lexical decision and valence identification tasks were employed in depressed and undepressed adult samples (Siegle, Granholm, Ingram, & Matt, 2001). Greater sustained pupil dilation (after a response is given for a given trial) was observed in depressed group compared to control group in response to evaluating to emotional aspect of stimuli. Greater sustained pupillary response to emotional information was replicated in a subsequent study (Siegle, Steinhauer, Carter, Ramel, & Thase, 2003). In these findings, the absence of difference between pupillary responses to positive and negative stimuli for depressed groups in emotional tasks challenges the mood-congruency account. Persistent processing, which is indexed by sustained pupil dilation, appears to reveal a reverse pattern for non-emotional experimental tasks used with participants with affective disorders. In a classical Stroop color-naming task, depressed group performed similarly to healthy group (Siegle, Steinhauer, & Thase, 2004). In other words, both groups were equivalently slower to name incongruent stimuli. At physiological level, greater dilation in pupils in incongruent trials was also comparable. Difference between patients and controls was found during the long inter-stimulus-interval (12s), where a decrease in pupil dilation was observed for depressed participants. The authors used a computational model and suggested that decreased sustained pupillary response is related to less prefrontal activation and therefore implies disrupted cognitive control. Sustained dilation in pupils shows sustained cognitive load (Laeng, Sirois, & Gredeback, 2012) and this was demonstrated to be at higher levels in depressed individuals for emotional tasks (Siegle et al., 2001; Siegle et al., 2003). An inverse pattern was evident for non-emotional tasks (Siegle et al., 2004). Another study employed pupillometry to compare high- and low-anxious participants in terms of reactivity to emotional and neutral face stimuli and in terms of attentional bias to threat-related distractors (Hepsomali, Hadwin, Liversedge, & Garner, 2017). While pupil dilation was larger in response to angry compared to happy faces for both groups, high-anxious group demonstrated larger pupil dilation than the low-anxious group for all emotional expressions.

In cognitive domain, pupillometry was suggested as an inexpensive alternative to neuroimaging due to a positive relationship between prefrontal activity and pupillary responses (Siegle, Steinhauer, Friedman, Thompson, & Thase, 2011). Cognitive control, which is mainly mediated by DLPFC, is suggested to be reflected in pupil size (Brown et al., 1999; van der Wel & Steenbergen, 2018). In order to associate pupillary and neural responses, Siegle and his colleagues administered the same tasks in pupillometry and fMRI settings for healthy (2003) and depressed participants (2011). They found a positive relationship between pupil diameter and DLPFC activity for both populations. In more recent studies, pupil diameter was repeatedly shown to be covary with locus coeruleus (LC) activity (Gilzenrat, Nieuwenhuis, Jepma, & Cohen, 2010; Larsen & Waters, 2018; Murphy, O'Connell, O'Sullivan, Robertson, & Balsters, 2014; see Figure 2.9 for the neural pathway of pupil dilation). This finding was extended by Joshi, Li, Kalwani, and Gold (2016) by showing that not only pupils dilate simultaneously with LC activity at rest and during task performance, but also micro-stimulation of the LC results in pupil dilation in monkeys. The locus coeruleus-norepinephrine system is involved in a wide range of brain functions including attention, memory, decision making, learning (see Sara, 2009 for a review) and sensory processing (see McBurney-Lin, Lu, Zuo, & Yang, 2019 for a review). Therefore, pupil response broadly reflects cortical processing.

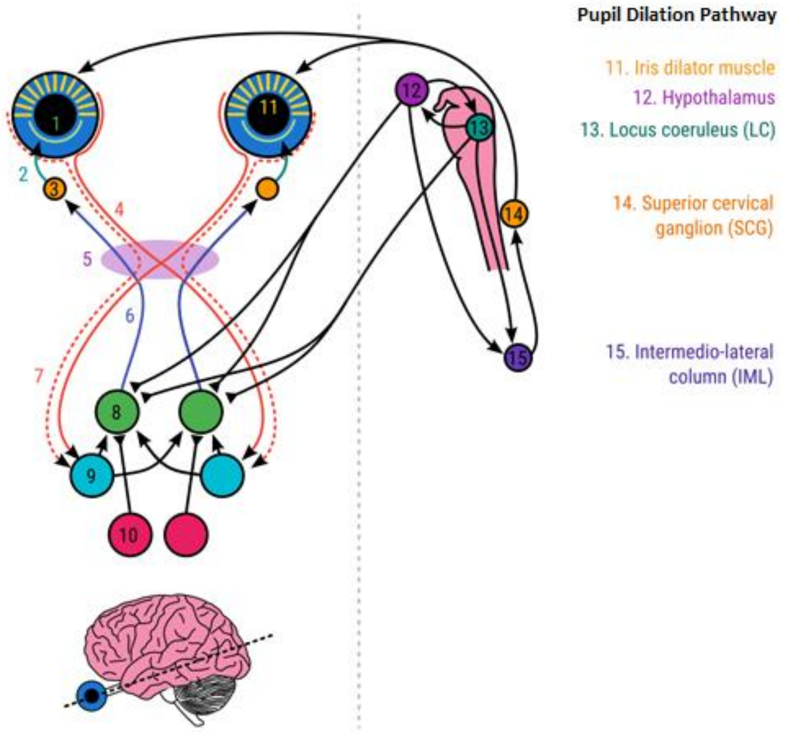


Figure 2.9. The Neural Pathway of Pupil Dilation (Mathot, 2018)

Pupil dilation was associated with cognitive control on the ground that cognitive tasks that require more effort induce grater dilation in pupils. The use of PD measurement as an index of cognitive demand in cognitive control tasks include arithmetical operations (Jainta & Baccino, 2010), n-back (Brouwer, Hogervorst, Holewijn, & van Erp, 2014; Hopstaken, van der Linden, Bakker, & Kompier, 2015), digit-span (Johnson, Miller Singley, Peckham, Johnson, & Bunge, 2014), and conflict tasks (Geva, Zivan, Warsha, & Olchik, 2013; Laeng, Orbo, Holmlund, & Miozzo, 2011; Rondeel, van Steenbergen, Holland, & van Knippenberg, 2015; van Steenbergen & Band, 2013). For example, studies using the word-color Stroop task found that incongruent trials leaded to increased pupil dilation compared to congruent and neutral trials (Laeng et al., 2011; Rondeel et al., 2015). Similarly,

incongruent trials were shown to elicit greater pupil dilation than congruent and neutral trials in the flanker task (Geva et al., 2013) and in the Simon task (van Steenbergen & Band, 2013). In another study employing a visuospatial monitoring task combined with one or two simultaneous tasks, it was demonstrated that increased task demands resulted in increased pupil dilation (Lisi, Bonato, & Zorzi, 2015). In a recent review, pupil dilation was suggested to closely relate to cognitive effort in three main executive functions, namely updating, shifting and inhibition (van der Wel & Steenbergen, 2018).
In emotion regulation studies, findings are mixed in terms of the direction of change in pupil size. For example, in an eye-tracking experiment participants were asked either to attend to negative pictures naturally or to reappraise/suppress their emotional response. Results showed smaller pupil size during both reappraise and suppress conditions compared to attend condition (Bebko et al., 2011). The authors interpreted this result as diminished emotional arousal when either emotional regulation strategy was used. Conversely, in other studies, pupil size was reported to be larger during both upregulation and downregulation of negative images relative to attending to them, which was accompanied by prefrontal activation (Urry, van Reekum, Johnstone & Davidson, 2009; van Reekum et al., 2007). These results point to cognitive effort during emotion regulation. A more recent study draws attention to the time course of pupil response during emotion regulation. Kinner and colleagues (2017) asked participants to maintain, upregulate, or downregulate their emotions or distracted them with an arithmetic problem. They found that during the early stages (0-2 sec.), upregulation, downregulation, and distraction, i.e. all emotion regulation strategies, leaded to increased pupil dilation compared to maintenance, i.e. passive viewing. However, during the later stages (2-5 sec.), upregulation of emotional response leaded to greater dilation in pupils compared to other conditions. These results suggested that while early phase of pupil response was associated with cognitive effort exerted to regulate emotion, later phase was associated with emotional arousal. In the same study, the finding that larger pupil size in response to passively viewing negative pictures than neutral ones emerges only on the later stages supports this interpretation. Other studies investigated individual differences in emotion regulation using pupil dilation measure. In a cued passive viewing paradigm, it was observed that for participants with high reappraisal scores, larger pupil size during anticipation reliably predicted smaller pupil size during exposure to both positive and negative pictures, this pattern was not observed for participants with high suppression scores (Vanderhasselt, Remue, Ng, & De Raedt, 2014).

Of primary interest for the present thesis, executive control was demonstrated to reduce the influence of emotional distracters both behaviorally (Cohen et al., 2011) and neurally (e.g. Melcher at al., 2011). This pattern was supported in a pupil dilation paradigm (Cohen, Moyal, & Henik, 2015). In their experiment, Cohen and colleagues (2015) presented an arrow flanker task (five arrows displayed side by side) with congruent (all five arrows pointing the same direction) and incongruent trials (middle arrow pointing the opposite direction to the surrounding arrows). The flanker task was followed by negative or neutral images after an interval. When congruent stimuli preceded the images, negative information elicited greater dilation in the pupil size compared to neutral information. This effect disappeared when incongruent stimuli preceded the images, eliciting similar pupil dilation for negative and neutral information. These findings suggest that PD measurement can be a valuable tool in studying the interaction between cognitive load and emotional distraction.

CHAPTER 3

METHOD

The methodological details of the present experiment, including participant demographics, mood assessment, materials, procedure, experimental design and data analysis are explained in the following parts.

3.1. Participants

Forty volunteers participated in the experiment: 20 females and 20 males with a mean age of 29 years (± 5.5). The age range was between 21 and 41 years. All participants had normal or corrected-to-normal vision. Volunteers with neurological diseases and currently using psychiatric medication were excluded from the study. All participants provided written informed consent form (Appendix A). Ethical approval was granted by Middle East Technical University Human Research Ethical Committee (Appendix B).

Table 3.1. Summary of Participant Demographics and Psychometrics

		Untrained Group (n = 20)	Trained Group (n = 20)
Gender (Female / Male)		10 / 10	10 / 10
Age (Years)		28.8 (5.7)	29.1 (5.2)
Education (Years)		16.9 (3.1)	17.5 (2.9)
Job Status (Employed / Unemployed)		13 / 7	11 / 9
BDI Score		6.5 (4.2)	6.2 (4.7)
S-ANX Score		34.3 (6.5)	33.6 (7.5)
T-ANX Score		40.2 (8.8)	40.4 (8.0)
PANAS Score	PA	33.1 (5.3)	34.2 (5.8)
	NA	17.6 (6.8)	17.1 (5.2)

Note. The data are presented as mean (standard deviation) format. BDI: Beck Depression Inventory, S-ANX: State Anxiety Subscale, T-ANX: Trait Anxiety Subscale, PANAS: Positive and Negative Affect Schedule, PA: Positive Affect, NA: Negative Affect. N: Number of Participants in Each Category, M: Mean Value.

One group of participants was assigned to the trained condition (n = 20, 10 females) and completed an intensive executive control training task. Another group was assigned to the untrained condition (n = 20, 10 females) and completed a simple identification training task. Demographic information about participants, which was collected using a pretest questionnaire (see Appendix C) were summarized in Table 3.1. Mean age, $t(38) = -0.174$, $p = 0.86$, and mean years of education, $t(38) = -0.581$, *p* = 0.57, was comparable between the groups. The two groups were equivalent in terms of gender distribution and job status. Mood assessment was also implemented before the experiment. Table 3.1 shows the results of the psychometric tests (see Section 3.2) for each group. The groups did not differ significantly in depression score, $t(38) = 0.176$, $p = 0.86$, state anxiety, $t(38) = -0.292$, $p = 0.77$, and trait anxiety scores, $t(38) = -0{,}075$, $p = 0{,}94$, or positive affect, $t(38) = -0.653$, $p = 0.52$, and negative affect scores, $t(38) = -0.288$, $p = 0.76$, according to independent samples t-tests.

3.2. Psychometric Tests

Before taking part in the experiment, participants completed a series of online psychometric tests. There was a set of three well-known questionnaires: Beck Depression Inventory (BDI), State and Trait Anxiety Inventory (STAI), and Positive and Negative Affect Schedule (PANAS). Participants answered them in the same order.

3.2.1. Beck Depression Inventory (BDI)

Beck Depression Inventory is a widely used, 21-item, self-report, multiple-choice inventory to measure severity of depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Consistently with the criteria in Third Edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-III) (Oliver & Simmons, 1984), it is based on physical, emotional, cognitive, and behavioral symptoms of depression.

Participants were asked to respond by selecting one alternative out of four choices in a continuum, which ranges from non-symptomatic (scoring 0) to intensely symptomatic (scoring 3) on a given item. Therefore, total sum of scores ranges from 0 to 63. Scores between 0 and 9 indicates none or minimal depression, scores between 10 and 18 indicates mild depression, scores between 19 and 29 indicates moderate depression, and scores between 30 and 63 indicates severe depression. In the present study, participants' BDI scores in both groups were identically distributed to each severity category; within each group, 15 participants scored between 0 and 9 (none/minimal depression), and five participants scored between 10 and 18 (mild depression).

Hisli (1989) validated the inventory in Turkish population. The adapted Turkish version can be found in Appendix D. In the present study, the sample is Turkish, so the cut-off point was selected as 17, as recommended by Hisli (1989). Volunteers with BDI score higher than 17 were excluded from the study. Table 3.1 shows the mean depression scores and standart deviations for the two groups of participants.

3.2.2. State and Trait Anxiety Inventory (STAI)

State and Trait Anxiety Inventory is a 40-item, self-report inventory to assess two types of anxiety in two separate 20-item subscales. Its current form was developed by Spielberger and colleagues (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The first subscale, State Anxiety Subscale (S-Anx), measures the current emotional state by asking respondents how they feel "right now". The subscale includes 10 items on feelings of worry, tension, and nervousness. There are 10 reverse items including feelings of calmness, comfort and relaxation (items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20). The Trait Anxiety Subscale (T-Anx) measures a relatively stable tendency to be anxious as a personal characteristic by asking respondents how they feel "in general". The subscale includes 13 anxiety-present items such as worry and restlessness and 7 anxiety-absent reverse items such as confidence and security (items 21, 26, 27, 30, 33, 36, and 39).

All items in both subscales are rated on a 4-point Likert scale. In S-Anx, choices range from “not at all” (scoring 1) to “very much so” (scoring 4). In T-Anx, choices range from “almost never” (scoring 1) to “almost always” (scoring 4). While calculating the scores, responses to anxiety-present items are summed and responses to reverse items are subtracted from the total score. Also, a constant, 50 for S-Anx and 35 for T-Anx, is added to the respective scores so that the resulting scores change between 20 and 80. Lower scores indicate lower levels of anxiety and higher scores indicate higher levels of anxiety for both types.

Öner and LeCompte (1985) adapted the scale in Turkish (see Appendix E). Table 3.1 shows the mean state and trait anxiety scores for the two groups of current participants. According to Kolmogorov-Smirnov tests, the anxiety scores were normally distributed within the groups for S-Anx and T-Anx (p's < 0.05 for both groups). State and trait anxiety scores were positively correlated, $r = 0.57$, $p < 0.001$, as was in literature (Spielberger & Reheiser, 2009). In addition, both state and trait anxiety scores were positively correlated with depression (BDI) score ($r = 0.52$, $p < 0.01$ for S-Anx and BDI and $r = 0.34$, $p < 0.05$ for T-Anx and BDI), which was in line with previous reports (Novy, Nelson, Goodwin, & Rowzee, 1993).

3.2.3. Positive and Negative Affect Schedule (PANAS)

Positive and Negative Affect Schedule is a 20-item, self-report scale to measure two primary dimensions of mood: Positive Affect (PA) and Negative Affect (NA). It was developed by Watson, Clark and Tellegen (1988). While PA is related to *activation* of pleasure, NA is related to *activation* of unpleasant mood states such as personal distress (Crawford & Henry, 2004). Each dimension is covered by 10 items. Each item is an emotion word associated with either positive dimension (interested, alert, attentive, excited, enthusiastic, inspired, proud, determined, strong, active) or negative dimension (distressed, upset, guilty, ashamed, hostile, irritable, nervous, jittery, scared, afraid). Each word is asked to be rated on a 5-point likert scale ranging from "very slightly or not at all" (scoring 1) to "extremely" (scoring 5). Therefore, resulting scores range from 10 to 50 for each dimension.

Gençöz (2000) studied validity and reliability of the scale in adapted Turkish version (see Appendix F). Table 3.1 shows the mean positive and negative affect scores for the two groups of participants.

3.3. Stimuli

In the present study, the Eriksen Flanker Task (Eriksen & Eriksen, 1974) was used in all three phases, namely training session, experiments 1 and 2. The stimuli were presented on a gray background throughout the whole procedure (RGB: 182, 182, 182). Experiment 1 included distracter pictures in addition to the target stimuli. The details of the flanker and distracter stimuli were explained separately in the following subsections.

3.3.1. Target Stimuli

The target stimuli consisted of five arrows displayed side by side, as a typical implementation of the Eriksen flanker task.There were two different arrow sets; one set consisted of vertical arrows and the other consisted of horizontal arrows. The arrows on the side pointed either congruent or incongruent direction with respect to the middle arrow (e.g. in the vertical set: congruent ↑ ↑ ↑ ↑ ↑, incongruent ↑ ↑ ↓ ↑ ↑, in the horizontal set: congruent → → → → →, incongruent → → ← → →). During the training, the arrows were shown vertically. During the subsequent experiments, the arrows were shown horizontally.

In the training session, for the untrained group, all arrows pointed up or down (congruent trials), making it a simple identification task. In the same session, for the trained group, in 30% of the trials, all arrows pointed the same direction (congruent trials); in 70% of the trials, the middle arrow pointed the opposite direction to the peripheral arrows (incongruent trials). Details of the stimuli in the training task were illustrated in Table 3.2. The task for the untrained group was to indicate, by keyboard button press, the pointing side of the middle arrow. For the trained group, the task was to indicate the opposite direction to the pointing side of the middle arrow, in order to increase the cognitive load. Since the task for the trained group includes an additional mental spatial transformation, it relies on multiple neurocognitive functions, including fronto-parietal areas (Zacks, Ollinger, Sheridan, & Tversky, 2002). In this session, each of the upward and downward arrows was 2.7 cm in height and there was a 3 cm space between each consecutive arrow. The total horizontal array of five arrows was 14 cm. The stimuli were viewed from 57 cm distance using a chin rest. The vertical visual angle was 2° and the horizontal visual angle was 14°.

The first experiment was identical for both participant groups. In this experiment, five flanker arrows pointed right or left. In half of the trials, all arrows pointed the same direction (congruent trials). In the other half, the middle arrow pointed the opposite direction to the peripheral arrows (incongruent trials). Details of the stimuli in Experiment 1 were illustrated in Table 3.2. In this experiment, the target stimuli were superimposed on emotional or neutral pictures (see section 3.3.2). The pictures were presented as distracters and did not require any responses. The task for all participants and all trials was to indicate the pointing side of the middle arrow by pressing the corresponding arrow keys.

In the second experiment, the first experiment was repeated without the pictures. Details of the stimuli in Experiment 2 were illustrated in Table 3.2. Arrows pointed the right or the left side. Half of the trials were congruent and the other half was incongruent. The task for all participants and all trials was to indicate the pointing side of the middle arrow by pressing the corresponding arrow keys.

Table 3.2. Details of the Arrow Flanker Stimuli in Each Phase for Each Participant Group.

<table>
<tr><th></th><th>Training</th><th>Experiment 1</th><th>Experiment 2</th></tr>
<tr><td>Untrained Group</td><td>100% congruent:
↑↑↑↑↑ (60)
↓↓↓↓↓ (60)</td><td rowspan="2">50% congruent:
→→→→→ (30)
←←←←← (30)

50% incongruent:
→→←→→ (30)
←←→←← (30)</td><td rowspan="2">50% congruent:
→→→→→ (20)
←←←←← (20)

50% incongruent:
→→←→→ (20)
←←→←← (20)</td></tr>
<tr><td>Trained Group</td><td>30% congruent:
↑↑↑↑↑ (18)
↓↓↓↓↓ (18)

70% incongruent:
↑↑↓↑↑ (42)
↓↓↑↓↓ (42)</td></tr>
</table>

Note. Parentheses show the total number of trials for each set of stimuli.

In Experiments 1 and 2, each arrow was 2.7 cm in width and there was a 0.5 cm space between each consecutive arrow, and the total horizontal display of five arrows was 15.5 cm. Each arrow vertically occupied 1.8 cm. The stimuli were viewed from 57 cm distance using a chin rest. The horizontal visual angle for the line of arrows was 15°.

3.3.2. Distracter Stimuli

Emotional and neutral distracter pictures in Experiment 1 were selected from the International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 1999, 2001, 2008). The IAPS is frequently used in emotion and attention studies (Bradley & Lang, 2007) focusing on physiological (e.g. Bradley, Miccoli, Escrig, & Lang, 2008), electrophysiological (e.g. D'Hondt et al., 2010; Keil et al., 2002; Styliadis, Ionnides, Bamidis, & Papadelis, 2015), and neuropsychological (e.g. Caria, Sitaram, Veit, Begliomini, & Birbaumer, 2010; Straube, Pohlack, Mentzel, & Miltner, 2008) correlates of emotional processing.

For the present experiment, five categories of pictures were created according to normative valence and arousal ratings. Each category was consisted of 12 pictures[1];

[1] The IAPS library numbers for the pictures in each distracter category are:
Neutral; 2102, 2191, 2272, 2273, 2377, 2390, 2411, 2745.1, 2840, 7057, 7130, 7632
Negative High Arousal; 2683, 2688, 2717, 3103, 9163, 9423, 9424, 9428, 9600, 9901, 9903, 9921
Negative Low Arousal; 2205, 2301, 2456, 2900.1, 3300, 9280, 9331, 9342, 9415, 9432, 9561, 9830
Positive High Arousal; 2216, 5621, 5623, 5833, 8030, 8170, 8190, 8200, 8370, 8490, 8496, 8501
Positive Low Arousal; 1463, 1920, 2057, 2070, 2091, 2151, 2165, 2224, 2340, 2398, 2530, 5210

there were 60 pictures in total. Details of the picture selection can be found in Table 3.3. As can be seen in the table, the two broader categories concern whether the pictures have emotional or neutral (non-emotional) content. The emotional pictures were further classified into four categories that addressed high and low segments of valence and arousal, in order to evaluate the contribution of these emotional dimensions to behavioral and physiological reactivity.

Table 3.3. Picture Selection Criteria and Mean Valence & Arousal Values for the Selected Pictures

		Emotional			
Picture Category	**Neutral**	**Positive High Arousal**	**Positive Low Arousal**	**Negative High Arousal**	**Negative Low Arousal**
Valence range	4.5 - 5.5	7 - 9	7 - 9	1 - 3	1 - 3
Mean Valence	5.13 (0.28)	7.63 (0.32)	7.71 (0.30)	2.42 (0.27)	2.67 (0.26)
Arousal Range	< 5	> 5.5	< 5	> 5.5	< 5
Mean Arousal	3.42 (0.56)	6.33 (0.54)	4.55 (0.26)	6.00 (0.35)	4.57 (0.30)

Note. The data are presented as mean (standard deviation) format.
Valence value shows the pleasantness of the picture and was rated on a 9-point likert scale (1-unpleasant and 9-pleasant) in the IAPS database. Arousal value shows the excitement/stimulation of the picture and was rated on a 9-point likert scale (1-calm and 9-excited) in the database.

Figure 3.1 shows the mean valence and arousal values in each category. The mean ratings and standard deviations for each picture can be found in Appendix G.

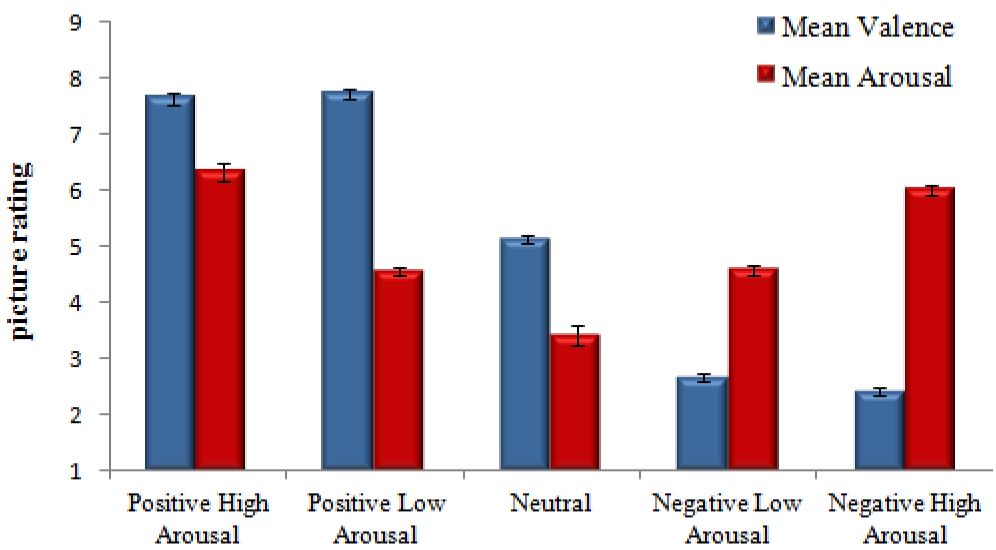


Figure 3.1. Mean Valence and Arousal Ratings for Each Distracter Category
Error Bars Show ±1 Standard Error

Mean valence values of pictures in each distracter category were compared using one-way ANOVA. Post-hoc tests using Tukey's HSD showed that while negative high arousal pictures did not differ from negative low arousal pictures in terms of valence (p = 0.23), this category differed from other three categories significantly (all p's < 0.001). Mean valence for neutral pictures were significantly different from all other categories (all p's < 0.001). Positive high arousal pictures did not differ from positive low arousal pictures in terms of valence (p = 0.96), it differed from other three categories significantly (all p's < 0.001). Mean arousal values in each distracter category were also compared using one-way ANOVA. While negative high arousal pictures did not differ from positive high arousal pictures in terms of arousal (p = 0.32), this category differed from other three categories significantly (all p's < 0.001). Mean arousal for neutral pictures were significantly different from all other categories (all p's < 0.001). Negative low arousal pictures did not differ from positive low arousal pictures in terms of arousal (p = 1), it differed from other three categories significantly (all p's < 0.001).

Cultural relevance of the pictures was taken into account during the selection process. The content of the pictures (e.g. human presence) was counterbalanced between distracter categories. Picture content for each category was summarized in Table A1 (see Appendix H). In order to avoid the effect of luminosity on pupil diameter across conditions, pictures were preprocessed and normalized. First, colored IAPS pictures were converted to grayscale, and then, intensity values were standardized using Adobe Photoshop 7.0. Average intensity value for all 60 images was calculated and each pictures' intensity was approximated to the average value. Before adjustment, the mean intensity was 114.5 (± 39.8) with a range of 43 and 208.9. After adjustment, the mean intensity was 111.82 (± 1.8) with a range of 108.7 and 114.9. The adjusted images were checked using the SHINE Toolbox (Willenbockel et al., 2010) in MATLAB (R2017a). The similarity indexes for pictures were examined in terms of luminance- and contrast-match (RMSE = 7.49, SSIM = 0.96) and histogram-match (RMSE = 18.75, SSIM = 0.85). The pictures were 12.1cm in height and 16.2cm in width. The stimuli was viewed from 57cm distance using a chin rest. The corresponding vertical visual angle was 12° and the horizontal visual angle was 16°.

For demonstration trials, one neutral picture was selected (valence = 4.96 and arousal = 2.83). The mean intensity value of the demonstration picture was set to 111.7. For practice trials, six additional neutral pictures were selected (mean valence = 5,04 ± 1,8 and mean arousal = 3.41 ± 0.62). The mean intensity value for the practice pictures was 112.4 (± 0.8) after adjustment.

3.4. Apparatus

The data was collected at Eye-Tracking Labaratory in UMRAM (National Magnetic Resonance Research Center) in Aysel Sabuncu Brain Research Center, Bilkent University, Ankara. The experimental program was designed in Java 8.2 and embedded in Netbeans 8.2 software to present the stimuli. Participants' responses indicating the side of the middle arrow in each trial and reaction times were recorded through the keyboard. Pupil diameters were recorded monocularly from the right eye using Applied Science Laboratories (ASL) Eye-Track 6. Pupil data was collected using ASL Eye-Trac 6000.Net User Interface software, which displays real time serial data for pupil diameter and gaze coordinates. Data rate was 50 Hertz. The eye-tracking camera was mounted below the Stimulus PC, a 21" HP NEC MultiSync LCD 2190UXP monitor with Windows 10 operating system. The visual stimuli were displayed at a 60 Hz refresh rate with a screen resolution of 1600x1200 pixels. The tracking distance was 57 cm using a chin rest. The Control Unit of the ASL Eye-Track-6 and the Control PC was placed on another desk in the lab. The lab setting can be seen in Figure 3.2. The experimenter administered the data collection process through the Control PC, a 21" HP NEC MultiSync LCD 2190UXP monitor with Windows 10 operating system.

Figure 3.2. The Laboratory Setting

3.5. Procedure

Volunteers who agreed to take part in the study were asked to abstain from caffeine, smoking, and alcohol in the day of experiment. Figure 3.3 shows the schematic representation of the experimental procedure. Participants first responded to online questionnaires, which included demographic information and psychometric tests (BDI, S-ANX, T-ANX, and PANAS). There were 95 items in total and it took about 20-30 minutes to complete the whole battery. And then, training and two subsequent experiments were carried out, each phase being preceded by brief demonstration and practice steps. All phases were initiated by pressing the space bar. Before starting any data collection, nine-dot standard eye-tracker calibration was done.

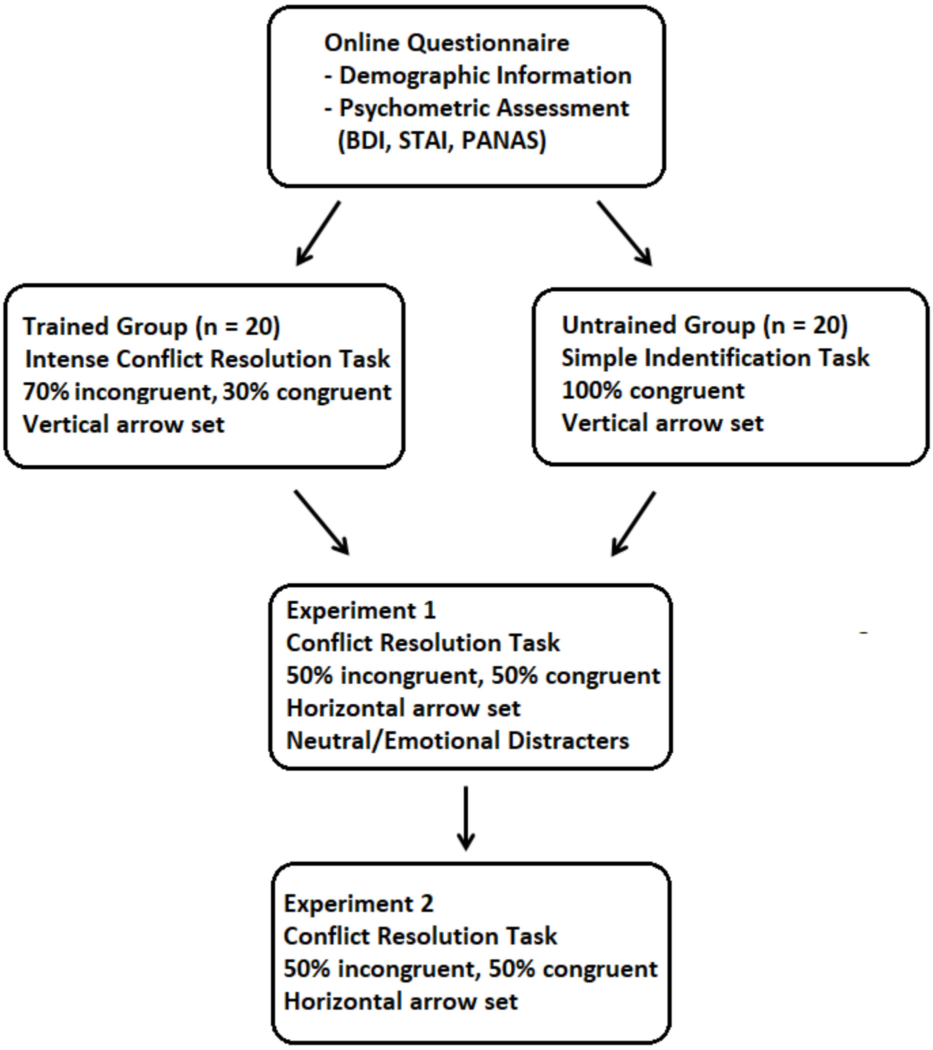


Figure 3.3. Schematic Representation of the Experimental Procedure

The training session was conducted first. Before starting the session, participants were instructed using demonstration trials with four up and down arrows according to their group. The response keys, up and down arrows on the keyboard, were matched to the up and down choices, respectively for the untrained group and inversely for the trained Group. The participants were asked to use their right index finger to press the down key and right middle finger to press the up key. The demonstration display was the same as the real trials, but the stimuli were displayed by the experimenter pressing the space bar. The observers were told that the trials would be the same as the demonstration, but it would run spontaneously. The participants also completed a practice with 12 trials, running same as the real experiment. They were instructed to respond as quickly and accurately as possible.

After the response, the color of the arrows changed from black (RGB: 0, 0, 0) to gray (RGB: 64, 64, 64) in order to make sure that a response was made and the next trial started. Each trial consisted of a line of five black arrows, which turned gray after the response and stayed on the screen to complete 3000 ms for adequate collection of pupil responses. There were no inter-trial-intervals (ITIs) in the training. There were 120 congruent trials for the untrained group. There were 36 congruent and 84 incongruent trials for the trained group. Therefore, the training took six minutes to complete. Correct choices were counterbalanced. Trials were presented in a pseudo random order. The procedure of the training for the two groups was illustrated in Figure 3.4.

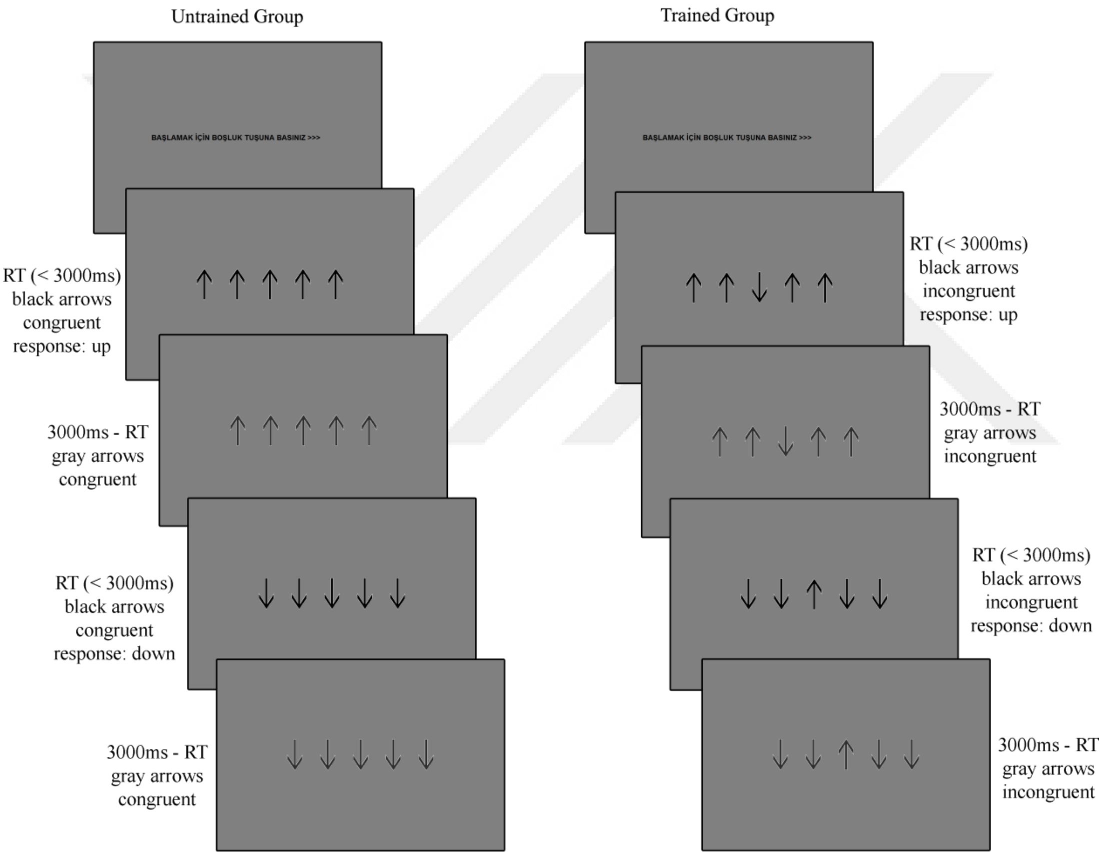


Figure 3.4. Procedure of the Training for the Untrained and Trained Groups

In Experiment 1, all participants were instructed using four demonstration trials with right and left arrows on a neutral picture. They were told that the pictures do not require any responses; the task is to indicate the pointing side of the middle arrow. The response keys, right and left arrows on the keyboard, were matched to the right and left choices respectively by the experimenter pressing the corresponding key for all trials. The participants were asked to use their right index finger to press the left key and right middle finger to press the right key. The demonstration display was the same as the real trials, but the stimuli were displayed by the experimenter pressing the space bar. The observers were told that the trials would be the same as the demonstration, but it would run spontaneously. The participants also completed a practice with 12 trials (six congruent and six incongruent) with six neutral pictures, running same as the real experiment. They were instructed to respond as quickly and accurately as possible. After the response, the color of the arrows changed from black (RGB: 0, 0, 0) to gray (RGB: 64, 64, 64) in order to make sure that a response was made. Each trial started with a line of five black arrows on a background picture, arrows turned gray after the response and stayed on the screen to complete 3000 ms for adequate collection of pupil responses. Three seconds of stimulus presentation is typical in studies measuring pupil response to emotional stimul (Bradley & Lang, 2015; Wang et al., 2018). Peak pupil dilation in response to emotional stimuli was also obtained around the third second of stimulus presentation (Bistricky, Ingram, Siegle, & Short, 2015). Experiment 1 included 1500 ms ITIs with a fixation cross (2 x 2 cm). There were 60 congruent and 60 incongruent trials. Therefore, the first experiment took nine minutes to complete. Each distracter picture was presented twice (once with congruent arrows and once with incongruent arrows). Correct choices were counterbalanced. Trials were presented in a pseudo random order. The procedure of the first experiment was illustrated in Figure 3.5.

In Experiment 2, all participants were instructed using demonstration trials with four right and left arrows. The response keys, right and left arrows on the keyboard, were matched to the right and left choices, respectively by the experimenter pressing the corresponding key for all trials. The participants were asked to use their right index finger to press the left key and right middle finger to press the right key. The demonstration display was the same as the real trials, but the stimuli were displayed by the experimenter pressing the space bar. The observers were told that the trials would be the same as the demonstration, but it would run spontaneously. The participants also completed a practice with 12 trials, running same as the real experiment. After the response, the color of the arrows changed from black (RGB: 0, 0, 0) to gray (RGB: 64, 64, 64) in order to make sure that a response was made. Each trial started with a line of five black arrows, which turned gray after the response and stayed on the screen to complete 3000 ms for adequate collection of pupil responses. There were no ITIs in the second experiment. There were 40 congruent and 40 incongruent trials. Therefore, the second experiment took four minutes to complete. Correct choices were counterbalanced. Trials were presented in a pseudo random order. The procedure of the second experiment was illustrated in Figure 3.6.

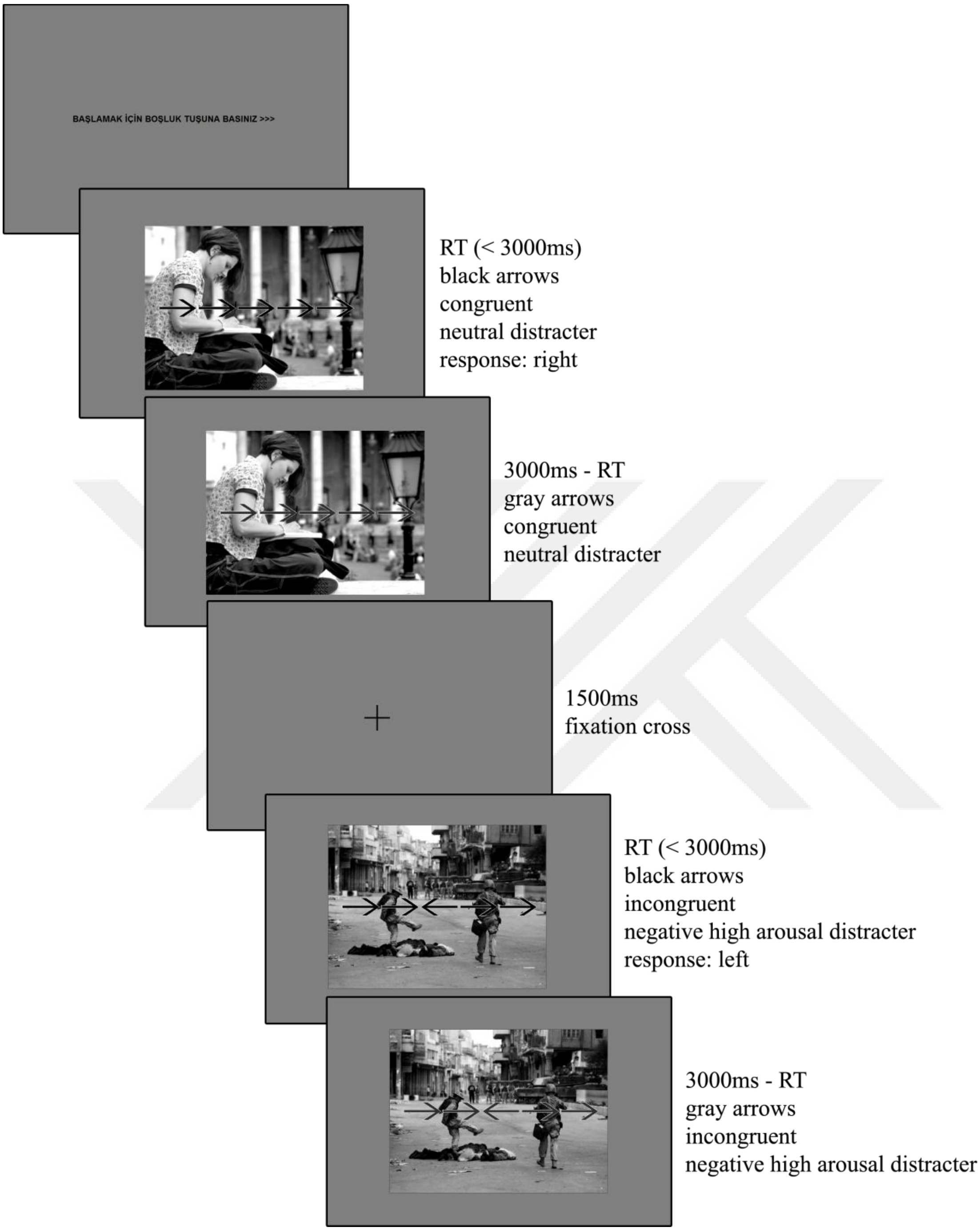


Figure 3.5. Procedure of Experiment 1 for Both Groups

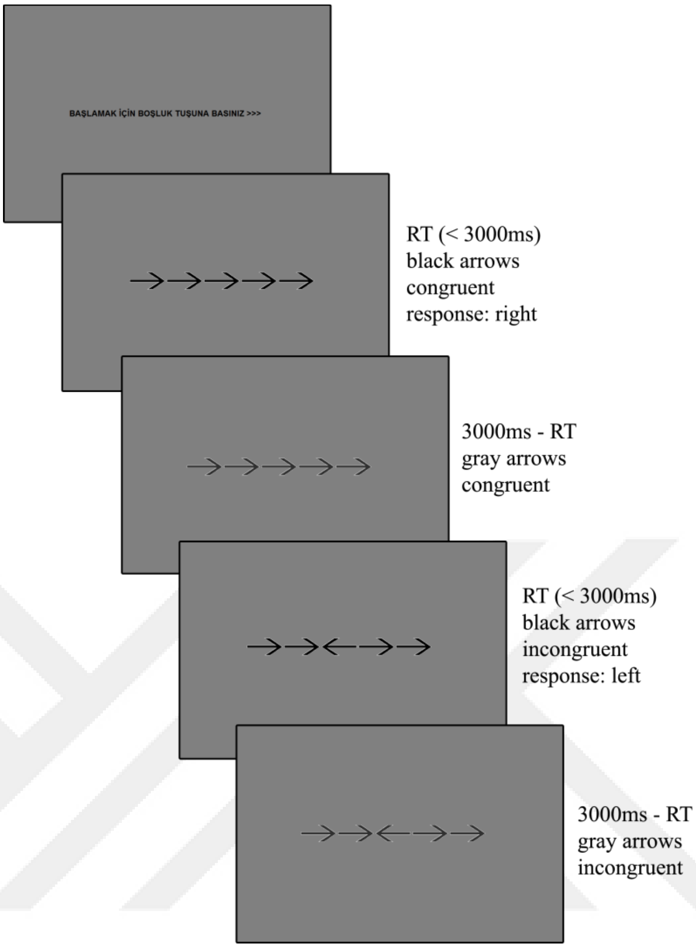


Figure 3.6. Procedure of Experiment 2 for Both Groups

After the three phases were completed, the participants were thanked for taking part in the experiment and were given the debriefing form (Appendix I), which explains the purpose of the study, experimental manipulations, expected results, and contact information of the experimenter, the supervisor, and the ethical committee.

3.6. Experimental Design

The first experiment of the study employed a 2x2x5 design, with one between-subjects and two within-subjects factors. The independent variables (IVs) were:

IV1: Training group with two levels; untrained group (simple identification training) and trained group (executive control training), according to the training task they completed,

IV2: Flanker congruity with two levels; congruent flanker arrows and incongruent flanker arrows for all participants, and

IV3: Distracter category with five levels; neutral, positive high arousal, positive low arousal, negative high arousal, and negative low arousal.

Experiment 2 employed a 2x2 design, with one between-subjects and one within-subjects factors. The independent variables were:

IV1: Training group with two levels; untrained group (simple identification training) and trained group (executive control training), according to the training task they completed, and

IV2: Flanker congruity with two levels; congruent flanker arrows and incongruent flanker arrows for all participants.

3.7. Data Processing

For the training session, accuracy scores were calculated as the percent correct responses due to different number of trials in different conditions. For the experimental phases, accuracy scores were calculated as the average number of correct responses in each condition of the corresponding experiment.

Reaction times (RT) in milliseconds were converted to z-scores for each participant. And then, incorrect responses were discarded. Finally, trials with a RT that is larger or smaller than three standard deviations from the participant's grand mean were excluded. Before calculating average RTs on specific conditions, outliers within the two groups were checked. Participants with mean RT that is larger or smaller than three standard deviations from their group's grand mean were regarded as outliers and excluded from analyses. Due to this criterion, there was one participant in the untrained group whose data was excluded from the RT analyses in training and one participant's data in the trained group was excluded from Experiment 1.

In addition to the main analyses, participants' conflict scores (RT incongruent - RT congruent) were calculated and separate analyses were conducted on these scores in Experiment 1. For the RT data, conflict adaptation effect (Padmala et al., 2011; Ullsperger, Blysma, & Botnivick, 2005), was also calculated. Conflict adaptation refers to reduced interference effect following incongruent trials compared to congruent trials. It is calculated as $(iI - iC) < (cI - cC)$, where the uppercases stand for the current trial (n) as incongruent (I) and congruent (C) and lowercases stand for the previous trial (n-1) as incongruent (i) and congruent (c).

Pupillary response was measured as pupil size in millimeters. The pupil responses for each participant were first preprocessed using a MATLAB (R2017a) code designed for the current analysis. The first step in the preprocessing was to detect missing data, which were recorded as zero, as a result of eye blinks. For each participant, the average pupil size and the standard deviation of the mean were calculated disregarding the zeros. Pupil measures that were four standard deviations below or above participant's mean were detected as outliers for artifact rejection (Kret & Sjak-Shie, 2019). And then, the missing data (zeros and one data point before and after each sequence of zeros) and the outliers were linearly interpolated (Kret, Stekelenburg, Roelofs, & de Gelder, 2013). If more than 30% of a trial was interpolated, that trial was excluded from the analysis. 5.1% of the total data was excluded in this fashion during the training, 3.2% during Experiment 1, and 5% during Experiment 2. In addition, if more than 30% of the total number of trials for a participant's data was interpolated, that participant was also excluded from the analysis (Korn & Bach, 2016). Based on this criterion, there was a single participant in the trained group whose data was excluded from training, and there were two participants in the untrained group whose data were excluded from Experiment 2.

The preprocessing procedures were similar for the training and the experimental phases. However, for Experiment 1, there were 1500 ms intervals with a fixation cross between the trials and also distracter pictures in the background during each trial. Due to these ITIs and picutres, there were two additional steps in the data processing stream in Experiment 1. First, the pupil data of the ITIs were discarded, since these parts were not informative. Second, when the pictures appeared on the screen, there was a sudden increase in luminance, which causes constriction of the pupils (McDougal & Gamlin, 2008). To detect this initial pupillary light reflex, a third-degree polynomial was fitted to the time series of each trial. If the local minimum of the fitted curve was within the first 1.5 seconds, then it was regarded as constriction (Bradley et al., 2008). In addition, it was also checked whether the slope of the regression line between the constriction point and the last data point was positive, which exhibits the typical pupillary response curve (Kinner et al., 2017; Nieuwenhuis, De Geus, & Aston-Jones, 2011). Trials for which constriction was not detected or slope after constriction was negative were excluded.

Standard preprocessing was applied in two steps. First of all, pupil diameters were normalized, because the initial pupil diameters in individual trials were quite variable across trials. The most common method is to specify a resting pre-trial period such as 500 ms and use the average pupil size in this period as baseline (Mathot, Fabius, Van Heusden, & Van der Stigchel, 2018). In the present study, subtractive baseline correction was applied as recommended (Mathot et al., 2018), but since the flow of the training and Experiment 2 did not include ITIs (so there were not any resting pre-trial periods) and for standardization purposes in Experiment 1, the value of the first data point in each trial was subtracted from the value of each data point in that trial. This can be visualized as shifting the initial data point to zero. Second, an adjustment was made to smooth the ripples in pupil diameters across each trial. For this purpose, moving average filter of a window size of 10 was applied.

Using the preprocessed data, for each trial, all pupil diameters were averaged and stored as the mean change in pupil size (i.e. pupil dilation) for that trial. For Experiment 1, this averaging had to be done not for the entire trial, but for the part of the trial after constriction point. And then, trials within specific conditions were averaged in order to compute each participant's pupil dilation for the experimental conditions.

3.8. Statistical Analyses

In the training session, accuracy scores, RTs on correct responses and changes in pupil size were separately averaged in the single condition (i.e. congruent) for the untrained group. These measures were averaged in congruent and incongruent conditions for the trained group. The groups were compared using independent samples t-tests in terms of dependent variables. Within the trained group, congruent and incongruent conditions were compared using paired samples t-tests.

In Experiment 1, each of the accuracy, RT on correct responses and change in pupil size measures were averaged for experimental conditions in the 5x2x2 design. There were three factors; a between-subjects factor of training group (two levels: untrained and trained) and two within-subjects factors of flanker congruity (two levels: congruent and incongruent) and distracter category (five levels: negative high arousal, negative low arousal, neutral, positive high arousal, and positive low arousal). In order to evaluate the effects of experimental manipulations, a three-way mixed analysis of variance (ANOVA) was conducted for each of the dependent variables, i.e. mean accuracy, mean RT on correct responses and mean change in pupil size. In Experiment 2, each of the accuracy score, RT on correct responses and change in pupil size measures were averaged for experimental conditions in the 2x2 design. There were two factors; a between-subjects factor training group (two levels: untrained and trained) and a within-subjects factor of flanker congruity (two levels: congruent and incongruent). A two-way mixed analysis of variance (ANOVA) was conducted for each of the dependent variables.

The variance analyses for reaction time and pupil dilation in Experiments 1 and 2 were followed by covariance analyses (ANCOVA) in order to evaluate and control for the effect of anxiety and depression on behavioral and physiological outcomes. State and trait anxiety and depression scores were separately used as covariates. For Experiment 1, three-way mixed ANCOVAs were conducted with one between-subjects factor of training group (two levels), two within-subjects factors of flanker congruity (two levels) and distracter category (five levels) and a covariate (state anxiety / trait anxiety / depression score) on reaction time and pupil dilation results separately. For Experiment 2, two-way mixed ANCOVAs were conducted with one between-subjects factor of training group (two levels), one within-subjects factor of flanker congruity (two levels) and a covariate (state anxiety / trait anxiety / depression score) on reaction time and pupil dilation results separately. Additionally, regression analyses were conducted for significant interactions between covariates and independent variables, in terms of the relation between dependent variable (RT or pupil dilation) and the covariate. Statistical Package for the Social Sciences (SPSS Inc., Version 17.0) was used for data analysis.

Before the covariance analyses were carried out, two assumptions of ANCOVA were checked. First of all, it was confirmed that the covariate and treatment effects were independent (Field, 2013, p.484); the two groups did not differ in terms of anxiety score, $t(37) = -0.114$, $p = 0.9$, and depression score, $t(37) = -0.02$, $p = 1$. Secondly, regression slopes between RT and mood scores was homogeneous between the groups for anxiety, $F(1,35) = 1.312$, $p = 0.26$, $\eta^2_p = 0.036$, and depression, $F(1,35) = 0.026$, $p = 0.9$, $\eta^2_p = 0.001$. Regression slopes between average change in pupil size and anxiety score was also homogeneous between the groups for anxiety, $F(1,36) = 0.121$, $p = 0.73$, $\eta^2_p = 0.003$, and depression, $F(1,36) = 0.019$, $p = 0.9$, $\eta^2_p = 0.001$.

CHAPTER 4

RESULTS

4.1. Training

In the training session, the trained group completed a high-frequent flanker task and the untrained group completed a simple identification version of the same task. The statistical analyses for behavioral and physiologial data in the training were explained separately in the following subsections.

4.1.1. Behavioral Results in the Training Session

Mean accuracy scores (i.e. percent correct responses) for the trained and untrained groups in the training flanker task can be seen in Table 4.1. Overall, accuracy scores seem to be at ceiling for both groups, although the trained group seems to be more accurate compared to the untrained group. The difference between the groups in congruent trials was marginally significant $t(38) = -2.012$, $p = 0.51$. Mean percent correct responses on congruent and incongruent conditions were not significantly different within the trained group, $t(19) = 1.486$, $p = 0.15$.

Table 4.1. Mean Accuracy (Percent Correct) and Reaction Time on Correct Responses for Each Group in the Training Flanker Task

Group	Flanker Condition	Accuracy (Percent Correct)	Reaction Time
Untrained	**Congruent**	97.8 (1.9)	681.5 (122.9)
Trained	**Congruent**	98.9 (1.8)	757.5 (116.4)
	Incongruent	97.9 (2.8)	792.6 (160.3)

Note. The data are presented as mean (standart deviation) format.

Table 4.1 shows the mean reaction time (RT) on correct responses in milliseconds for the untrained and trained groups on each condition of the training flanker task. For the trained group, task load was further increased by asking participants to indicate the opposite direction of the middle arrow. This instruction seems to produce the expected result, with slower RTs for the trained group in both congruent (76 ms) and incongruent trials (111 ms) compared to the untrained group. The RT difference between the groups was marginally significant in congruent trials, $t(37) = -1.981$, $p = 0.055$. The trained group seems to perform better on congruent trials compared to incongruent trials (see Figure 4.1). A paired samples t-test supported this observation; mean RT was significantly faster on congruent than incongruent trials, $t(19) = -2.708$, $p < 0.05$.

4.1.2. Physiological Results in the Training Session

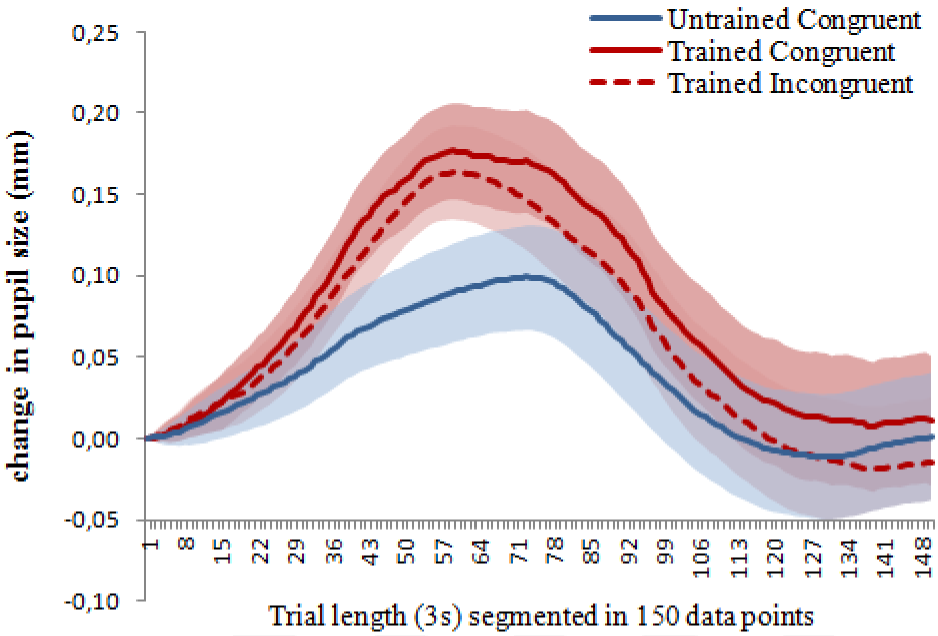


Figure 4.1. Average Time Series for Change in Pupil Size (millimeters)
Across Groups and Flanker Conditions in the Training Session
Upper and Lower Bounds Show ±1 Standard Error

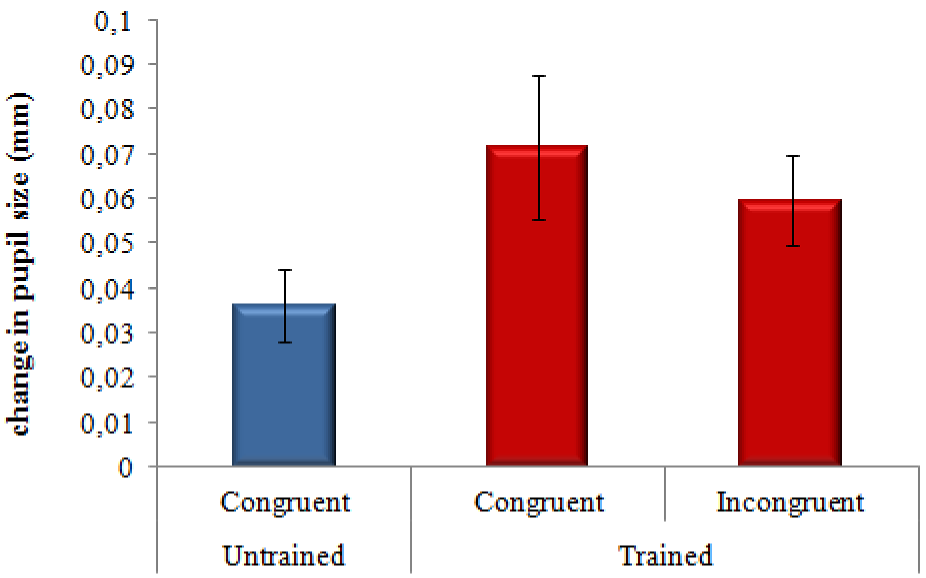


Figure 4.2. Mean Change in Pupil Size (millimeters)
for Both Groups in the Training Flanker Task
Error Bars Show ±1 Standard Error

Figure 4.1 shows the time series and Figure 4.2 shows the mean change in pupil size in millimeters for both groups in the training flanker task. In congruent trials, pupil dilation seems to be smaller for the untrained group compared to the trained group. The difference between the groups was marginally significant for the whole stimulus presentation period, $t(37) = -1.954$, $p = 0.06$, and significant between data points 30 and 100 (i.e. between 600 and 2000 ms), $t(37) = -2.314$, $p < 0.05$. Mean change in pupil size seems comparable between congruent and incongruent trials for the trained group, although congruent trials seem to elicit slightly greater pupil dilation. The difference between congruent and incongruent trials was not statistically significant, $t(18) = 0.824$, $p = 0.42$.

4.2. Experiment 1

In the first experiment, both groups completed the same flanker task, which was combined with neutral and emotional distracter pictures. The statistical analyses for behavioral and physiologial data in the first experiment were explained separately in the following subsections.

4.2.1. Behavioral Results in Experiment 1

Figure 4.3 shows the mean number of correct responses (out of 12) for each group on each condition of the Flanker task with emotional distracters. Overall accuracy performance by the two groups seems at ceiling, but there still seems to be some variation. A three-way mixed ANOVA with one between-subjects factor of training group (two levels: untrained and trained) and two within-subjects factors of flanker congruity (two levels: congruent and incongruent) and distracter category (five levels: negative high arousal, negative low arousal, neutral, positive high arousal, and positive low arousal) was conducted. The main effect of training group was not significant, $F(1, 38) = 0.835$, $p = 0.37$, $\eta^2_p = 0.022$. For within-subjects factors, while the main effect of congruity was significant, $F(1, 38) = 8.174$, $p = 0.007$, $\eta^2_p = 0.177$, the main effect of distracter category did not reach to significance, $F(4, 152) = 2.466$, $p = 0.075$, $\eta^2_p = 0.061$. In addition, none of the two-way interactions or the three-way interaction was statistically significant.

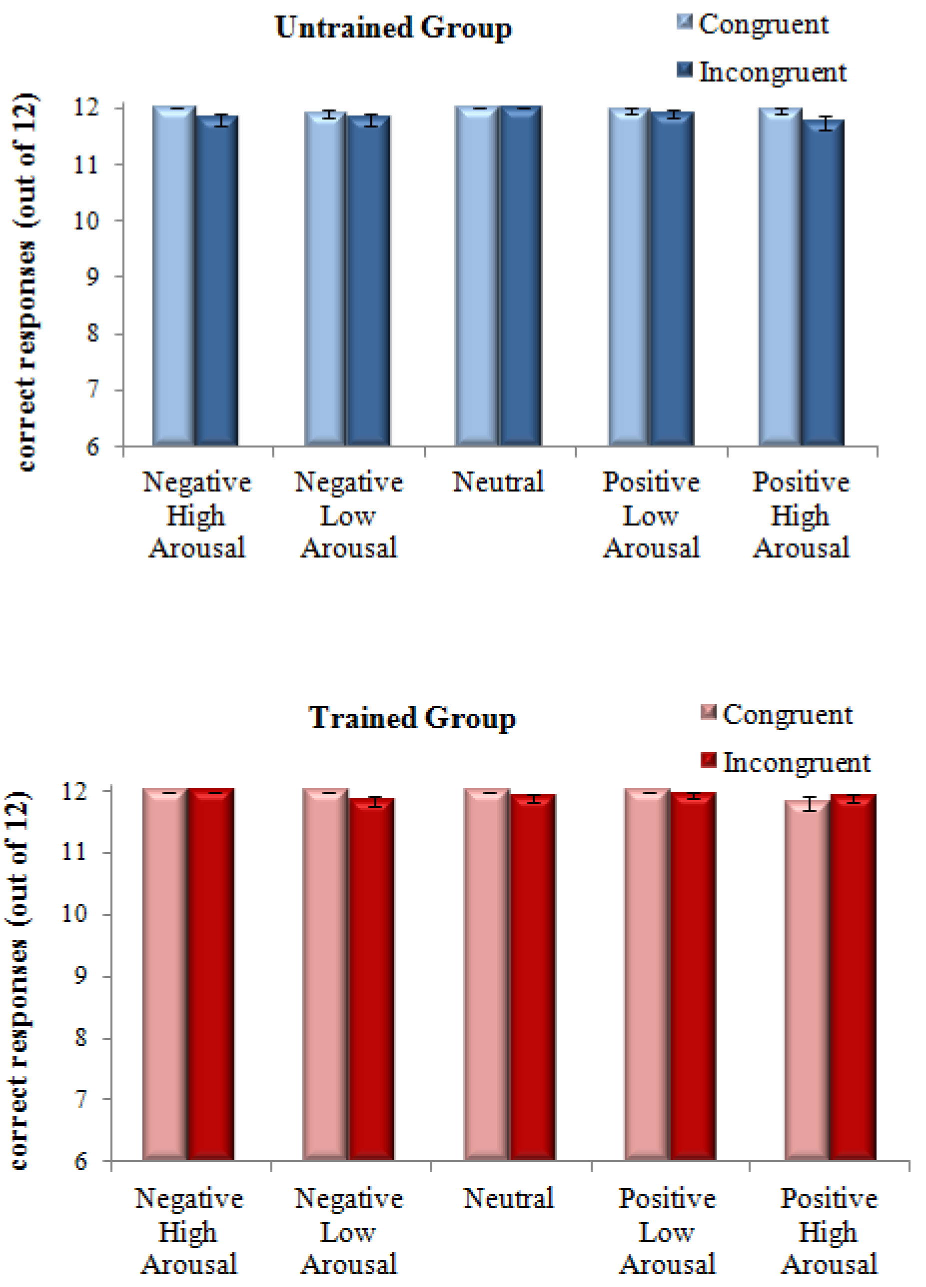
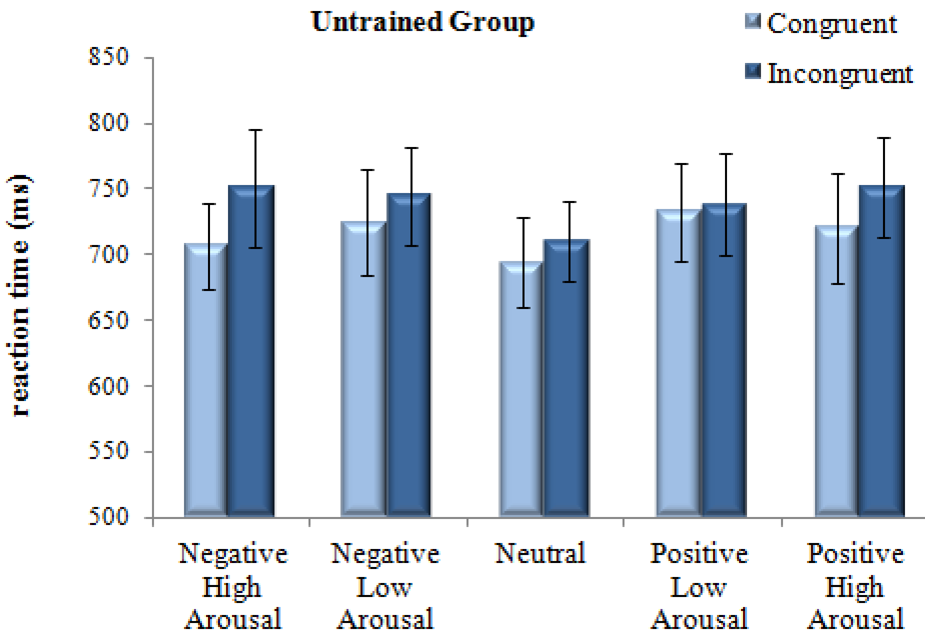


Figure 4.3. Mean Number of Correct Responses (out of 12)
for Each Group on the Flanker Task with Distracters
Error Bars Show ±1 Standard Error



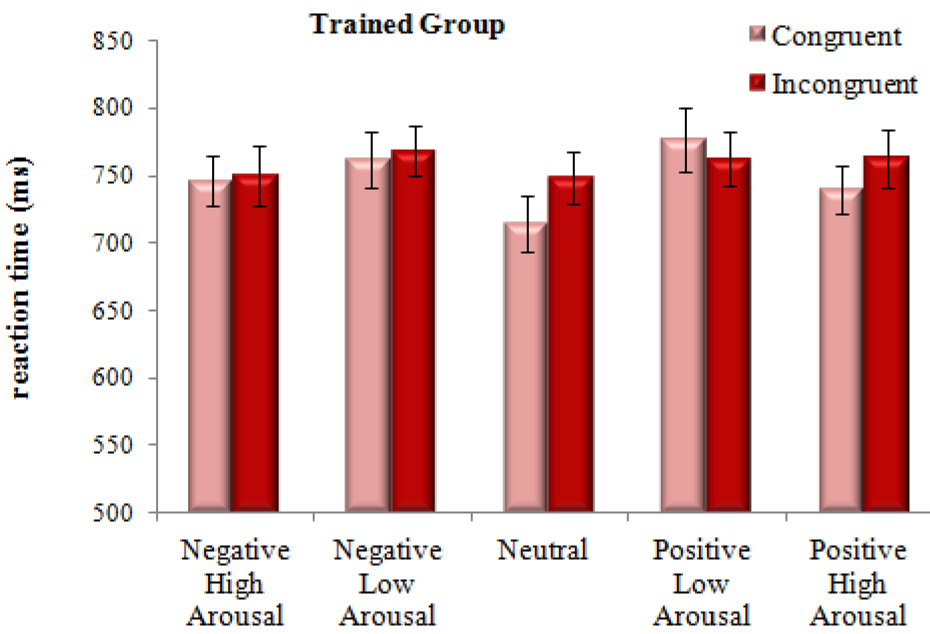


Figure 4.4. Mean Reaction Time on Correct Responses (milliseconds)
for Each Group on the Flanker Task with Distracters
Error Bars Show ±1 Standard Error

Figure 4.4 shows the mean reaction time on correct responses for each training group on each condition of the flanker task with distracters. Overall, RT seems to be slower in incongruent compared to congruent trials, irrespective of training group or distracter category. An augmented RT interference (RT incongruent > RT congruent) appears for the untrained group in high arousal distracter conditions. On the other hand, an augmented RT interference appears for the trained group in neutral condition. There are also fluctuations in RT for different distracter categories.

A three-way mixed ANOVA with one between-subjects factor of training group (two levels: untrained and trained) and two within-subjects factors of flanker congruity (two levels: congruent and incongruent) and distracter category (five levels: negative high arousal, negative low arousal, neutral, positive high arousal, and positive low arousal) was conducted (for a summary of the statistics, see Table 4.2). According to ANOVA results, the main effect of training group was not significant, $F(1, 37) = 0.349$, $p = 0.56$, $\eta^2_p = 0.009$. For within-subjects factors, both the main effect of flanker congruity, $F(1, 37) = 10.600$, $p < 0.01$, $\eta^2_p = 0.223$, and the main effect of distracter category were significant, $F(4, 148) = 9.478$, $p < 0.001$, $\eta^2_p = 0.204$. The interaction between distracter category and flanker congruity was not significant, $F(4, 148) = 1.097$, $p = 0.36$, $\eta^2_p = 0.029$. The training group X distracter category interaction, $F(4, 148) = 0.436$, $p = 0.78$, $\eta^2_p = 0.012$, and training group X flanker congruity interaction, $F(1, 37) = 0.394$, $p = 0.53$, $\eta^2_p = 0.011$, were not significant. The three-way interaction of distracter category X flanker congruity X training group was also non-significant, $F(4, 148) = 1.108$, $p = 0.35$, $\eta^2_p = 0.029$. For the significant main effects, pairwise comparisons with Bonferroni correction confirmed that RTs on incongruent trials were slower than congruent trials ($p < 0.01$), indicating a typical interference effect. In addition, Bonferroni corrected comparisons between levels of distracter category showed that neutral distracters were significantly associated with faster reaction times compared to all emotional distracters, namely negative high arousal ($p < 0.05$), negative low arousal ($p < 0.01$), positive high arousal ($p < 0.01$), and positive low arousal ($p < 0.001$). RTs for emotional distracters did not significantly differ from each other (all p's > 0.05).

In Experiment 1 for the RT measure, when state anxiety score was used as a covariate in a three-way mixed ANCOVA, the flanker congruity X distracter category interaction, $F(4, 140) = 2.517$, $p < 0.05$, $\eta^2_p = 0.067$ and the flanker congruity X distracter category X training group interaction, $F(4, 140) = 3.339$, $p < 0.05$, $\eta^2_p = 0.087$ became significant. Follow-up tests with Bonferroni correction for the three-way interaction yielded that the behavioral interference effect (RT incongruent > RT congruent) was significant for the untrained group when distracters were positive highly arousing, $F(1, 35) = 7.565$, $p < 0.01$, $\eta^2_p = 0.178$ and marginally significant when the distracters were negative highly arousing, $F(1, 35) = 3.428$, $p = 0.07$, $\eta^2_p = 0.089$. For the trained group, the interference effect was significant only when the distracters were neutral, $F(1, 35) = 5.228$, $p < 0.05$, $\eta^2_p = 0.130$. In addition, follow-up tests for RT differences in distracter category levels revealed that in congruent trials, emotional distracters with low arousal delayed RTs compared to neutral distracters for both untrained group, $F(4, 32) = 2.854$, $p < 0.05$, $\eta^2_p = 0.263$, and trained group, $F(4, 32) = 4.527$, $p < 0.01$, $\eta^2_p = 0.361$. In incongruent trials, while RTs did not differ between distracter categories for the trained group, $F(4, 32) = 1.745$, $p = 0.16$, $\eta^2_p = 0.179$, positive arousing distracters delayed RTs compared to neutral distracters for the untrained group, $F(4, 32) = 3.391$, $p < 0.05$, $\eta^2_p = 0.298$. The four-way interaction, i.e. flanker congruity X distracter category X training group X state anxiety, was also significant, $F(4, 140) = 4.006$, $p < 0.01$, $\eta^2_p = 0.103$. The significant four-way interaction was examined in terms of the relation between state anxiety score and RT for the different levels of independent variables. The only significant difference in the regression slopes was between the groups in incongruent trials with negative high arousal distracters, $b = 13.938$, $t(35) = 2.223$, $p < 0.05$, $\eta^2_p = 0.124$. State anxiety score was positively related to RT for the untrained group while it was negatively related to RT for the trained group (see Figure 4.5). For the remaining conditions, none of the beta values were statistically significant.

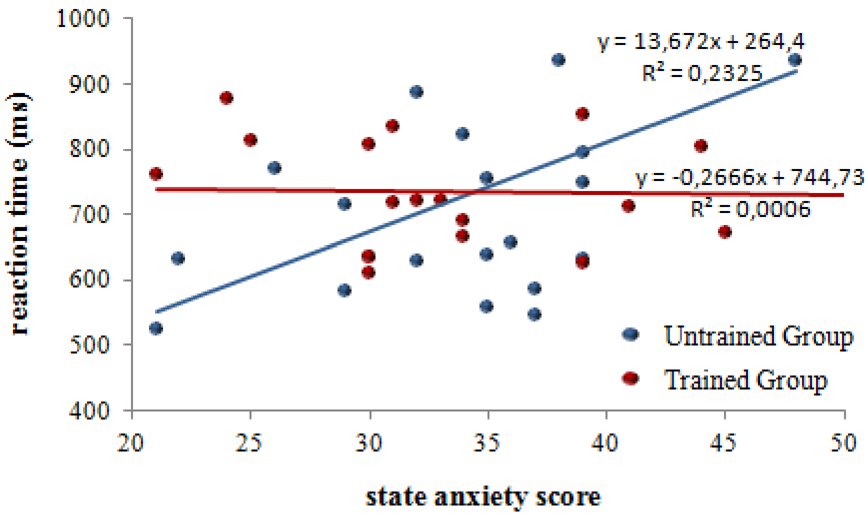


Figure 4.5. Relation Between State Anxiety Level and Reaction Time for Each Group in Incongruent Trials with Negative High Arousal Distracters in Experiment 1

Two additional three-way mixed ANCOVAs were conducted for the RT measure in Experiment 1, using trait anxiety score and depression score as covariates. None of the main or interaction effects were significant for these analyses (see Table 4.2).

Table 4.2. Summary of the Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA, for State Anxiety, Trait Anxiety, and Depression Scores Separately Used as Covariates) Results on Reaction Time on Correct Responses in the Flanker Task with Distracters

		ANOVA		**ANCOVA S-ANXIETY**		**ANCOVA T-ANXIETY**		**ANCOVA DEPRESSION**	
		F	η^2_p	***F***	η^2_p	***F***	η^2_p	***F***	η^2_p
Main Effects	**Congruity**	10.600**	0.223	1.689	0.046	1.314	0.036	3.948	0.101
	Distracter	9.478***	0.204	0.750	0.021	0.659	0.018	1.444	0.040
	Group	0.349	0.009	0.623	0.070	0.335	0.009	0.044	0.001
	S-Anxiety			2.777	0.074				
	T-Anxiety					1.635	0.045		
	Depression							1.113	0.031
Two-Way Interactions	**Congruity x Distracter**	1.097	0.029	2.517*	0.067	0.408	0.012	0.525	0.015
	Congruity x Group	1.576	0.041	2.574	0.069	0.578	0.016	0.965	0.027
	Distracter x Group	0.394	0.011	1.297	0.036	0.426	0.012	0.350	0.010
	Congruity x S-Anxiety			0.436	0.012				
	Distracter x S-Anxiety			1.414	0.039				
	Group x S-Anxiety			2.316	0.062				
	Congruity x T-Anxiety					0.315	0.009		
	Distracter x T-Anxiety					0.068	0.018		
	Group x T-Anxiety					0.242	0.007		
	Congruity x Depression							0.054	0.002
	Distracter x Depression							0.502	0.014
	Group x Depression							0.021	0.001
Three-Way Interactions	**Congruity x Distracter x Group**	1.108	0.029	3.339*	0.087	2.147	0.058	0.505	0.014
	Congruity x Distracter x S-Anxiety			2.248	0.060				
	Congruity x Group x S-Anxiety			2.271	0.061				
	Distracter x Group x S-Anxiety			1.595	0.044				
	Congruity x Distracter x T-Anxiety					0.250	0.007		
	Congruity x Group x T-Anxiety					0.440	0.012		
	Distracter x Group x T-Anxiety					0.570	0.016		
	Congruity x Distracter x Depression							0.535	0.015
	Congruity x Group x Depression							0.591	0.017
	Distracter x Group x Depression							1.098	0.030
Four-Way Interactions	**Congruity x Distracter x Group x S-Anxiety**			4.006**	0.103				
	Congruity x Distracter x Group x T-Anxiety					2.595	0.069		
	Congruity x Distracter x Group x Depression							0.680	0.019

*p < 0.05, **p < 0.01, ***p < 0.001

In addition to the main analyses, participants' conflict scores (RT incongruent - RT congruent) were calculated. Figure 4.6 shows the mean conflict score for each group in each emotional context. The untrained group seems to have larger conflict scores than the trained group for all emotional distracters. On the contrary, the trained group seems to have larger conflict score than the untrained group for neutral distracters.

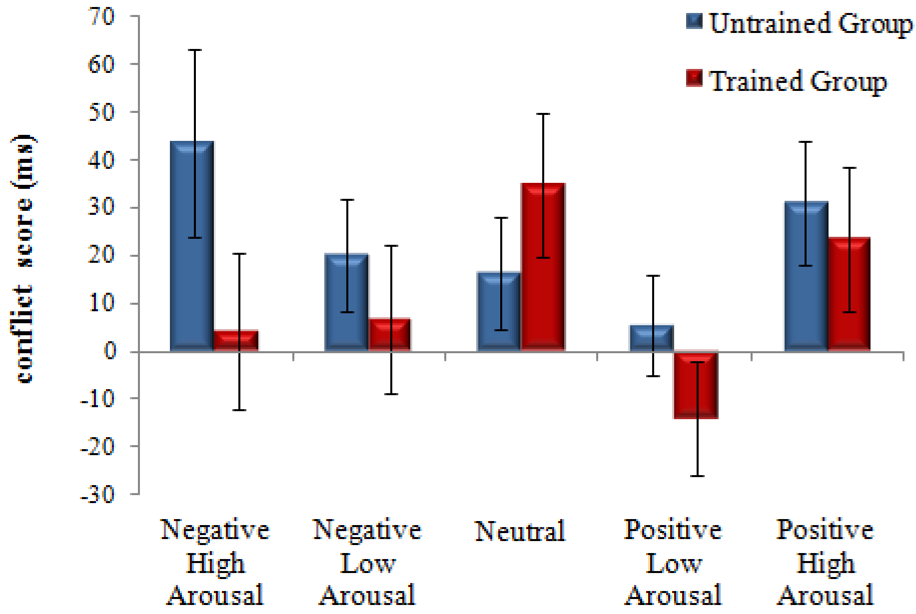


Figure 4.6. Behavioral Conflict Effect: Mean Conflict Score (milliseconds) in Each Distracter Category for Each Group
Error Bars Show ±1 Standard Error

A repeated measures ANOVA with one between-subjects factor of group (two levels: untrained and trained) and one within-subjects factors of distracter category (five levels: negative high arousal, negative low arousal, neutral, positive high arousal, and positive low arousal) was conducted. The main effect of group was not significant, $F(1, 37) = 1.576$, $p = 0.22$, $\eta^2_p = 0.041$, the main effect of distracter category was not significant, $F(4, 148) = 1.777$, $p = 0.14$, $\eta^2_p = 0.046$, neither the interaction between distracter category and group, $F(4, 148) = 1.119$, $p = 0.35$, $\eta^2_p = 0.029$.

Finally, the conflict adaptation effect (Padmala et al., 2011; Ullsperger, Blysma, & Botnivick, 2005), was calculated. Conflict adaptation refers to reduced interference effect following incongruent trials compared to congruent trials. It is calculated as (iI - iC) < (cI - cC), where the uppercases stand for the current trial (n) as incongruent (I) and congruent (C) and lowercases stand for the previous trial (n-1) as incongruent (i) and congruent (c). Figure 4.7 shows the conflict adaptation effect as the mean conflict score based on previous trial congruency in each distracter context for each group.

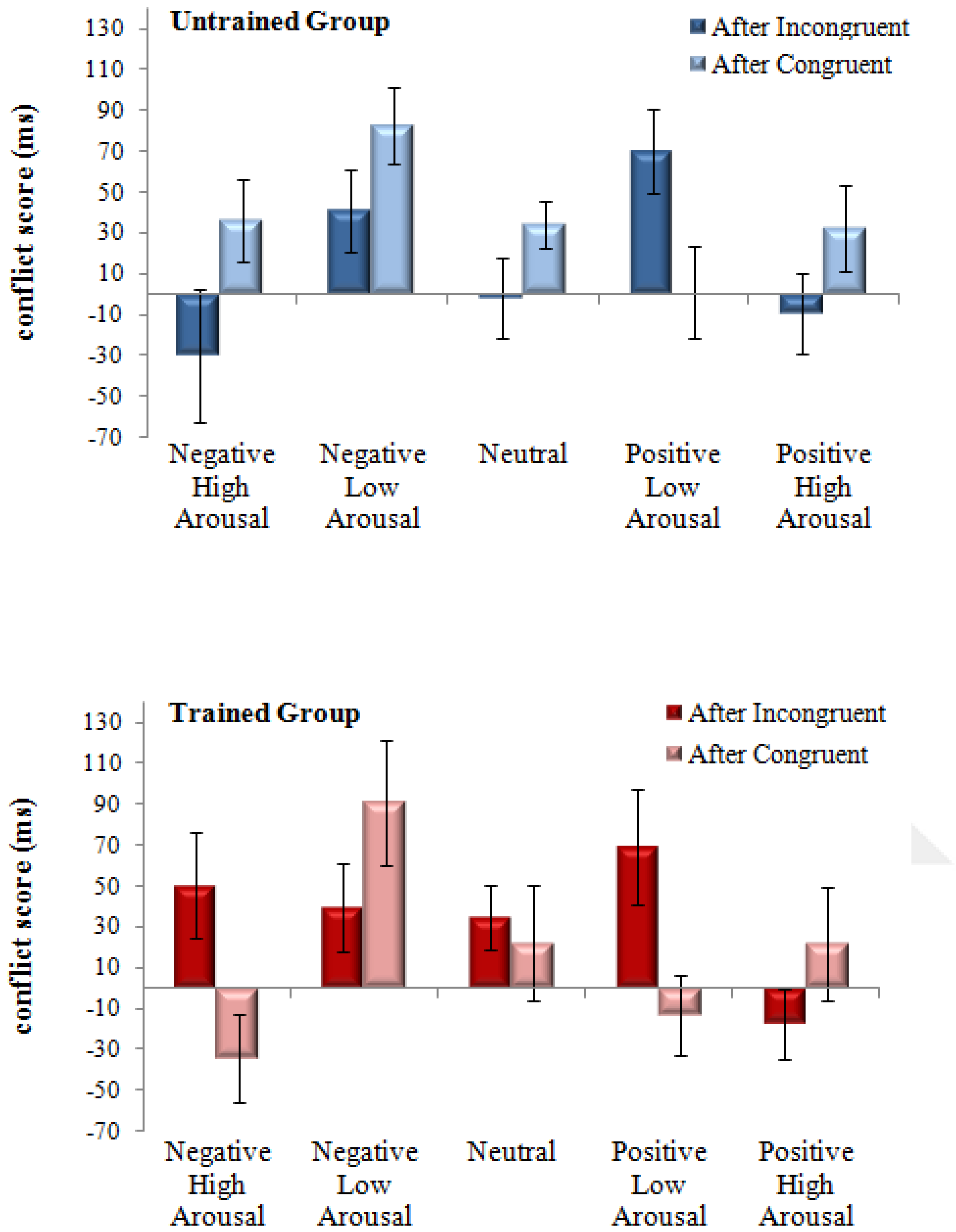


Figure 4.7. Conflict Adaptation Effect: Mean Conflict Scores Based on Previous Trial Congruency in Each Distracter Category for Each Group
Distracter Categories Refer to the Pictures in the Current Trial
Error Bars Show ±1 Standard Error

A three-way mixed ANOVA with one between-subjects factor of group (two levels: untrained and trained) and two within-subjects factors of previous trial congruity (two levels: congruent and incongruent) and emotional distracter category (five levels: negative high arousal, negative low arousal, neutral, positive high arousal, and positive low arousal) was conducted (for a summary of the results of statistical analyses, see Table 4.3). The main effect of training group was not significant, $F(1, 37) = 0.006$, $p = 0.94$, $\eta^2_p < 0.001$. For within-subjects factors, while the main effect of distracter category was significant, $F(3.1, 114.8) = 4.513$, $p = 0.005$, $\eta^2_p = 0.109$, the main effect of previous trial congruity was not, $F(1, 37) = 0.053$, $p = 0.82$, $\eta^2_p = 0.001$. The interaction between distracter category and previous trial congruity was statistically significant, $F(4, 148) = 5.124$, $p = 0.001$, $\eta^2_p= 0.122$. The interaction between group and these factors were not significant, $F(3.1, 114.8) = 0.168$, $p = 0.95$, $\eta^2_p = 0.005$ for distracter X group and $F(1, 37) = 2.918$, $p = 0.1$, $\eta^2_p = 0.073$ for previous trial congruity X group. The three-way interaction of distracter category X previous trial congruity X group was marginally significant, $F(4, 148) = 2.211$, $p = 0.07$, $\eta^2_p = 0.056$.

Table 4.3. Summary of the Statistical Analysis Results on Conflict Adaptation in the Flanker Task with Distracters

		ANOVA	
		F	η^2_p
Main Effects	**Previous trial congruity**	0.053	0.001
	Distracter category	4.513**	0.109
	Training group	0.006	< 0.001
Two-Way Interactions	**Previous trial congruity x Distracter category**	5.124**	0.122
	Previous trial congruity x Training group	2.918	0.073
	Distracter category x Training group	0.168	0.005
Three-Way Interactions	**Previous trial congruity x Distracter category x Training group**	2.211ǂ	0.056

**p < 0.01, ǂ indicates marginal significance

Post-Hoc tests with Bonferroni correction yielded that the conflict adaptation effect was marginally significant for the untrained group when distracters in current trial were negative highly arousing, $F(1, 37) = 3.726$, $p = 0.06$, $\eta^2_p = 0.091$. On the other hand, the trained group significantly demonstrated a reverse effect in this distracter category, $F(1, 37) = 5.806$, $p = 0.02$, $\eta^2_p = 0.136$. This means that the untrained group demonstrated a reduced interference effect after incongruent trials. Conversely, the trained group demonstrated an reduced interference effect after congruent trials.

4.2.2. Physiological Results in Experiment 1

Figure 4.8 shows the pupil dilation time series averaged across participants in each group, each flanker condition, and each distracter category in Experiment 1. For each participant and each trial, the value of the initial data point was shifted to zero (Section 3.7). Therefore the figure shows the average change in pupil size throughout stimulus presentation within specified conditions. Overall, the untrained group seems to have greater pupil dilation compared to the trained group. The two groups appear to differ from each other especially when the distracters were negative highly arousing, in which pupil response seems to be comparable between congruent and incongruent trials within both groups.

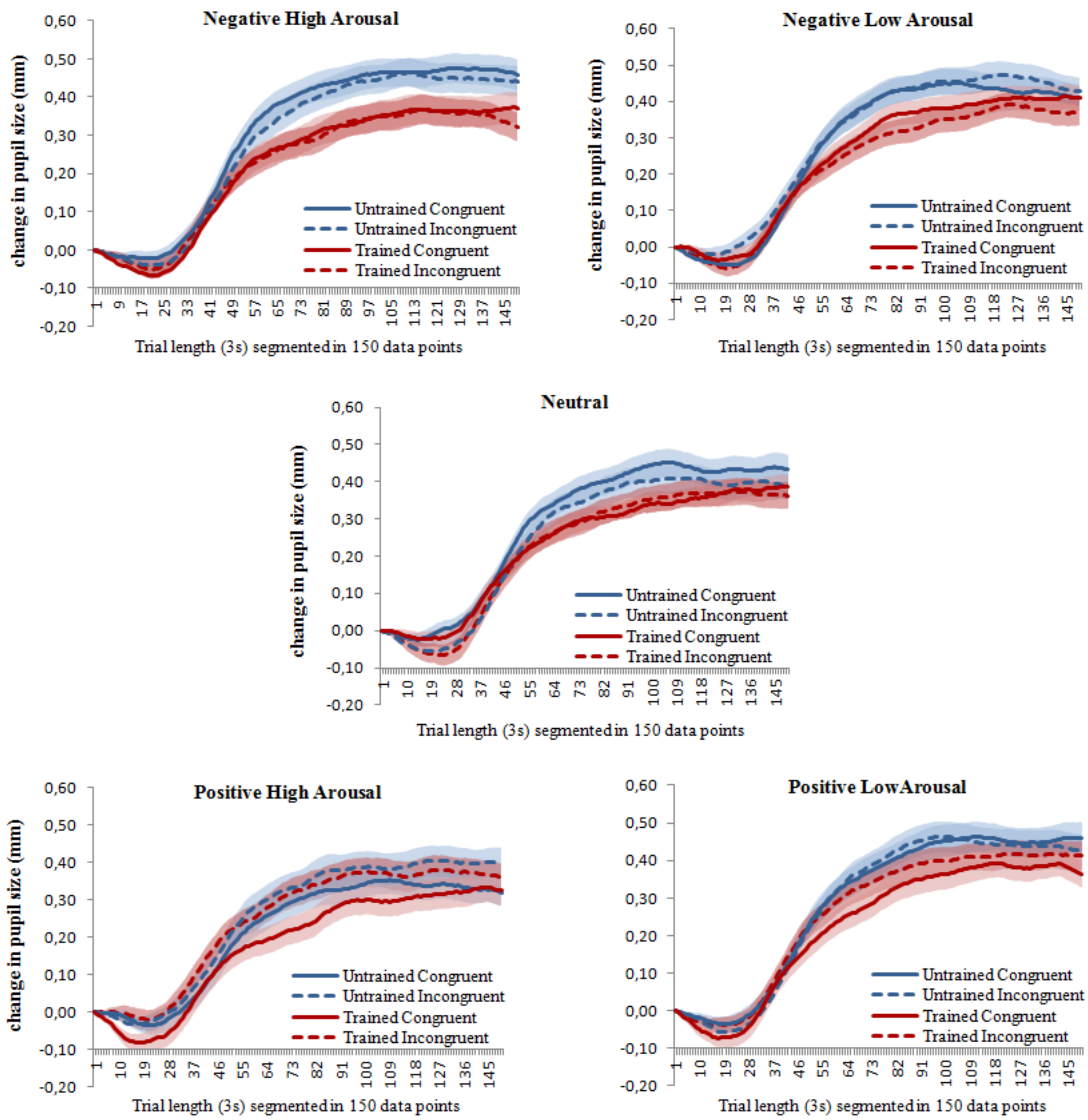


Figure 4.8. Average Time Series for Change in Pupil Size (millimeters)
in Each Condition of the Flanker Task with Distracters
Upper and Lower Bounds Show ±1 Standard Error

Figure 4.9 shows the average change in pupil size between 1.5-3 seconds of stimulus presentation (see Section 3.7). A three-way mixed ANOVA with one between-subjects factor of taining group (two levels) and two within-subjects factors of flanker congruity (two levels) and distracter category (five levels) was conducted (for a summary of the statistics, see Table 4.4). The main effect of group was not significant, $F(1, 38) = 1.495$, $p = 0.23$, $\eta^2_p = 0.038$. For within-subjects factors, while the main effect distracter category was significant, $F(4, 152) = 6.052$, $p < 0.001$, $\eta^2_p = 0.137$, the main effect of congruity was not, $F(1, 38) = 0.212$, $p = 0.65$, $\eta^2_p = 0.006$. The interaction between distracer category and congruity was non-significant, $F(3.65, 138.72) = 1.754$, $p = 0.15$, $\eta^2_p = 0.044$. The interaction between group and congruity was also non-significant, $F(1, 38) < 0.001$, $p = 0.97$, $\eta^2_p < 0.001$, whereas distracter category X group interaction was significant $F(4, 152) = 3.178$, $p < 0.05$, $\eta^2_p = 0.077$. The three-way interaction, distracter category X flanker congruity X group, was not statistically significant, $F(4, 152) = 0.520$, $p = 0.72$, $\eta^2_p = 0.014$.

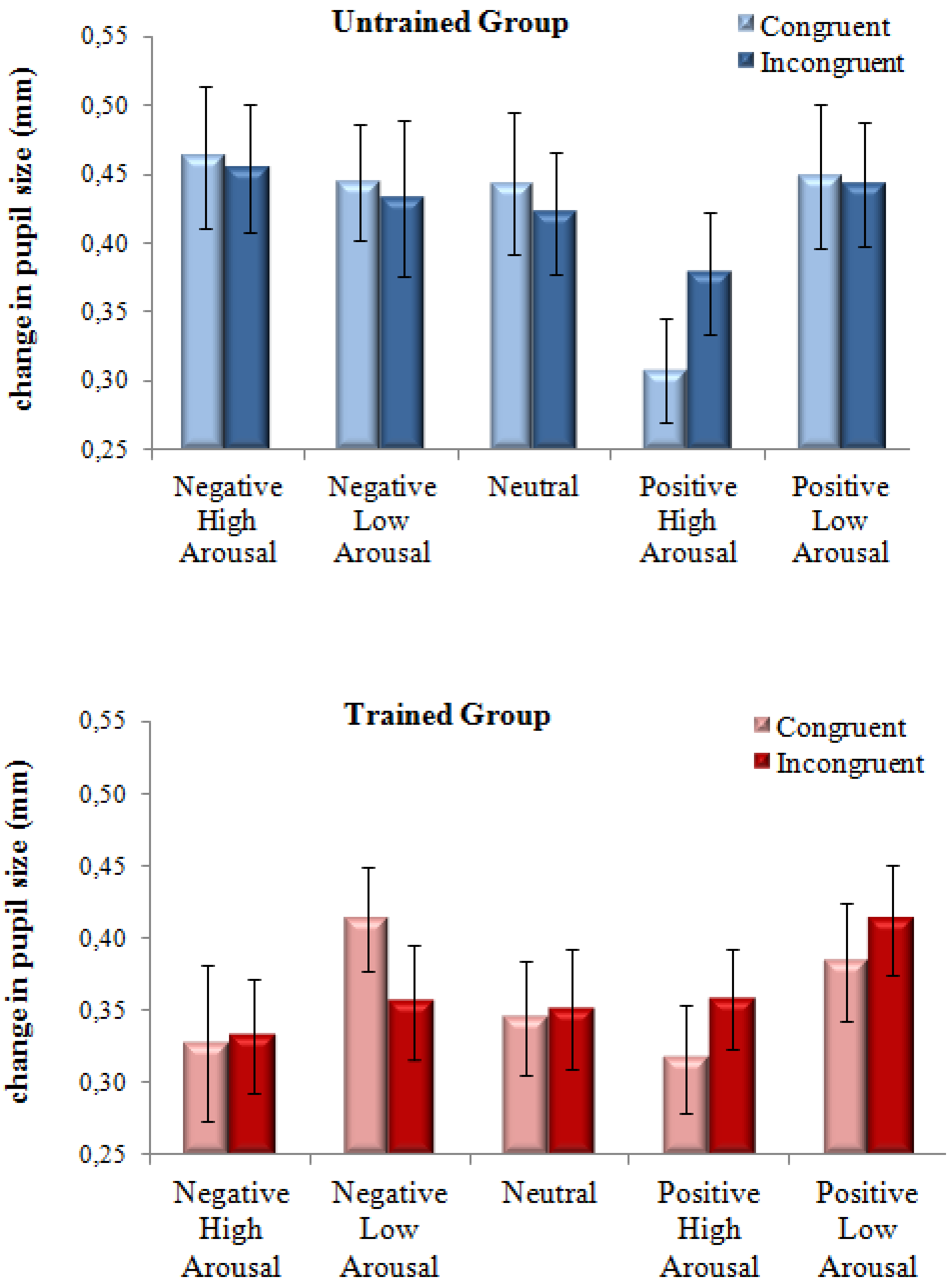


Figure 4.9. Average Change in Pupil Size (millimeters)
for Each Group on the Flanker Task with Distracters
Error Bars Show ±1 Standard Error

Post-Hoc tests with Bonferroni correction for the significant distracter category X training group interaction yielded that pupil dilation was smaller for the trained group compared to the untrained group in trials with negative high arousal distracters, $F(1, 38) = 4.057$, $p = 0.05$, $\eta^2_p = 0.096$. In addition, while the pupil dilation did not differ between distracter categories for the trained group, positive high arousal distracters were associated with smaller pupil dilation than all the other categories for the untrained group, $F(4, 35) = 5.891$, $p < 0.01$, $\eta^2_p = 0.402$.

In Experiment 1 for the pupil dilation measure, three separate three-way mixed ANCOVAs (see Table 4.4) revealed that while state anxiety did not significantly interact with the independent variables, the trait anxiety X flanker congruity X distracter category interaction was significant, $F(4, 144) = 2.817$, $p < 0.05$, $\eta^2_p = 0.073$. Using depression score as the covariate revealed significant flanker congruity X depression score interaction, $F(4, 144) = 8.156$, $p < 0.01$, $\eta^2_p = 0.185$.

In addition to the main analyses, pupillary interference effect, i.e. average change in pupil size in incongruent trials minus average change in pupil size in congruent trials, was calculated in each distracter category for each group. Figure 4.10 shows the mean conflict score in each distracter context for both groups. A repeated measures ANOVA with one between-subjects factor of training group (two levels) and one within-subjects factor of distracter category (five levels) revealed that he main effect of group was not significant, $F(1, 38) < 0.000$, $p = 1$, $\eta^2_p < 0.001$, the main effect of emotion was not significant, $F(3.22, 122.5) = 1.754$, $p = 0.16$, $\eta^2_p = 0.044$, neither the interaction between emotion and group, $F(3.22, 122.5) = 0.520$, $p = 0.7$, $\eta^2_p = 0.014$.

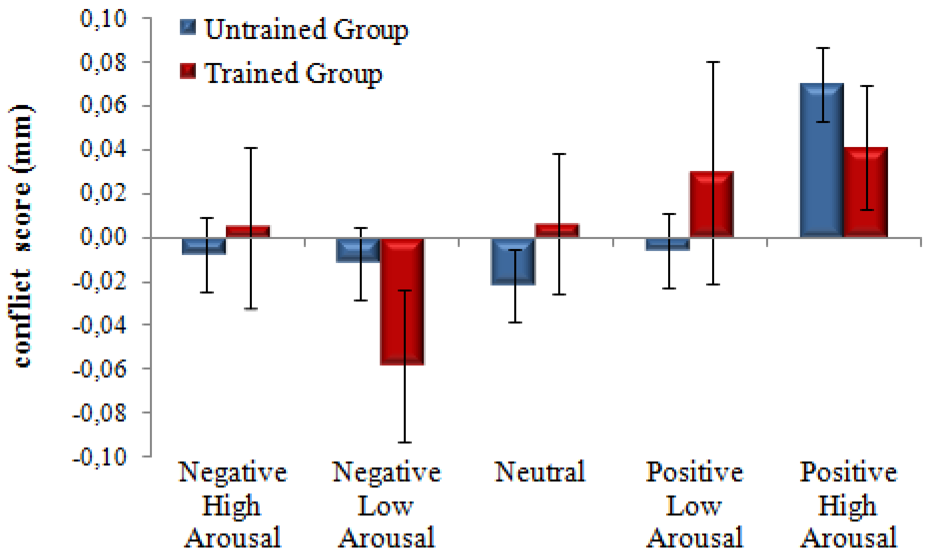


Figure 4.10. Pupillary Conflict Effect: Mean Conflict Score (millimeters) for Each Group in Each Distracter Category
Error Bars Show ±1 Standard Error

Table 4.4. Summary of the Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA, for State Anxiety, Trait Anxiety, and Depression Scores Separately Used as Covariates) Results on Average Change in Pupil Size in the Flanker Task with Distracters

		ANOVA		**ANCOVA S-ANXIETY**		**ANCOVA T-ANXIETY**		**ANCOVA DEPRESSION**	
		F	η^2_p	***F***	η^2_p	***F***	η^2_p	***F***	η^2_p
Main Effects	**Congruity**	0.212	0.006	3.411	0.087	1.094	0.029	7.006*	0.163
	Distracter	6.052***	0.137	0.317	0.009	0.644	0.018	4.328*	0.107
	Group	1.495	0.038	3.290	0.084	0.317	0.009	0.609	0.017
	S-Anxiety			0.090	0.002				
	T-Anxiety					2.690	0.070		
	Depression							0.402	0.011
Two-Way Interactions	**Congruity x Distracter**	1.754	0.044	1.460	0.039	2.554*	0.066	0.700	0.019
	Congruity x Group	< 0.001	< 0.001	1.016	0.027	2.529	0.066	0.734	0.020
	Distracter x Group	3.178*	0.077	0.822	0.022	0.708	0.019	1.585	0.042
	Congruity x S-Anxiety			3.241	0.083				
	Distracter x S-Anxiety			0.258	0.007				
	Group x S-Anxiety			2.584	0.067				
	Congruity x T-Anxiety					0.938	0.025		
	Distracter x T-Anxiety					0.965	0.026		
	Group x T-Anxiety					0.692	0.019		
	Congruity x Depression							8.156**	0.185
	Distracter x Depression							0.788	0.021
	Group x Depression							0.019	0.001
Three-Way Interactions	**Congruity x Distracter x Group**	0.520	0.014	1.280	0.034	0.819	0.022	0.818	0.022
	Congruity x Distracter x S-Anxiety			1.576	0.042				
	Congruity x Group x S-Anxiety			1.093	0.029				
	Distracter x Group x S-Anxiety			0.479	0.013				
	Congruity x Distracter x T-Anxiety					2.817*	0.073		
	Congruity x Group x T-Anxiety					2.623	0.068		
	Distracter x Group x T-Anxiety					0.447	0.012		
	Congruity x Distracter x Depression							0.448	0.012
	Congruity x Group x Depression							0.977	0.026
	Distracter x Group x Depression							0.463	0.013
Four-Way Interactions	**Congruity x Distracter x Group x S-Anxiety**			1.199	0.032				
	Congruity x Distracter x Group x T-Anxiety					0.799	0.022		
	Congruity x Distracter x Group x Depression							0.546	0.015

*p < 0.05, **p < 0.01, ***p < 0.001

4.3. Experiment 2

In the second experiment, both groups completed the same flanker task without distracter pictures. The statistical analyses for behavioral and physiologial data in the second experiment were explained separately in the following subsections.

4.3.1. Behavioral Results in Experiment 2

Table 4.5 shows the mean number of correct responses (out of 40) and the mean reaction time on correct responses for each training group in each flanker condition in Experiment 2. Overall accuracy performance by the two groups seems at ceiling. In addition, the mean number of correct responses seems to decrease in incongruent trials compared to congruent trials, irrespective of group. A two-way mixed ANOVA with one between-subjects factor of training group (two levels) and one within-subjects factor of flanker congruity (two levels) supported this observation. While the main effect of congruity was significant, $F(1, 38) = 7.393$, $p = 0.01$, $\eta^2_p = 0.163$, the main effect of group was not significant, $F(1, 38) = 0.004$, $p = 0.95$, $\eta^2_p < 0.001$, neither the interaction between congruity and group, $F(1, 38) = 0.315$, $p = 0.58$, $\eta^2_p = 0.008$.

Table 4.5. Mean Number of Correct Responses and Mean Reaction Time on Correct Responses for Each Group in the Flanker Task without Distracters

Training Group	Flanker Condition	Number of Correct Responses	Reaction Time
Untrained	Congruent	39.6 (0.6)	613.3 (135.5)
	Incongruent	39.2 (1.0)	666.4 (150.6)
Trained	Congruent	39.7 (0.5)	613.8 (97.2)
	Incongruent	39.1 (1.2)	647.1 (117.2)

Note. The data are presented as mean (standard deviation) format

The mean reaction time seems to increase in incongruent trials compared to congruent trials, irrespective of the group. A two-way mixed ANOVA with one between-subjects factor of training group (two levels: untrained and trained) and one within-subjects factor of flanker congruity (two levels: congruent and incongruent) supported this observation. While the main effect of flanker congruity was significant, $F(1, 38) = 31.202$, $p < 0.001$, $\eta^2_p = 0.451$, the main effect of group was not significant, $F(1, 38) = 0.057$, $p = 0.8$, $\eta^2_p = 0.001$, neither the interaction between flanker congruity and training group, $F(1, 38) = 1.624$, $p = 0.21$, $\eta^2_p = 0.041$.

In Experiment 2 for the reaction time measure, a two-way mixed ANCOVA with the state anxiety score as covariate (see Table 4.6) revealed that the interaction between training group and state anxiety was significant, $F(1, 36) = 4.223$, $p < 0.05$, $\eta^2_p = 0.105$. The three-way interaction between flanker congruity X training group X state anxiety was also marginally significant, $F(1, 36) = 3.617$, $p = 0.06$, $\eta^2_p = 0.091$. State anxiety score was positively related to RT for the untrained group, while it was negatively related to RT for the trained group. The difference between the groups was significant in incongruent trials (see Figure 4.11), b = 13.467, $t(36) = 2.273$, $p < 0.05$, $\eta^2_p = 0.125$.

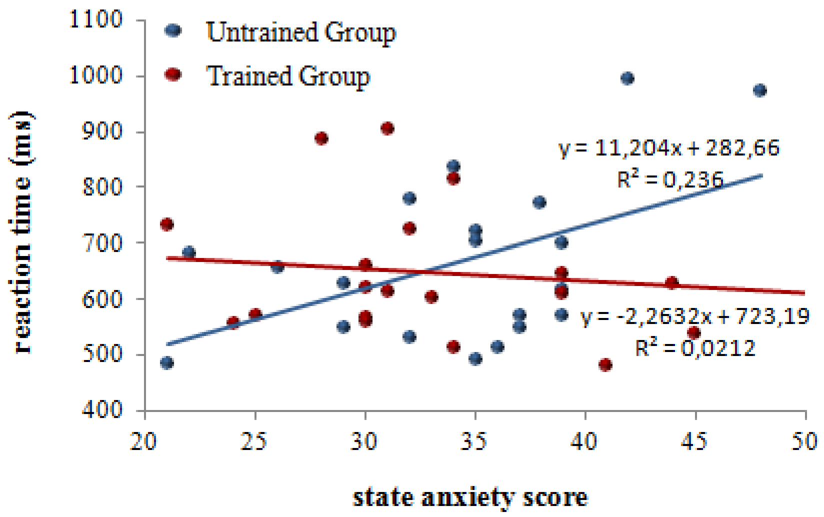


Figure 4.11. Relation Between State Anxiety Level and Reaction Time for Each Group in Incongruent Trials in Experiment 2

Two additional three-way mixed ANCOVAs were conducted using trait anxiety score and depression score as covariates. Neither trait anxiety nor depression score significantly interacted with the independent variables (see Table 4.6).

Table 4.6. Summary of the Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA, for Anxiety and Depression Scores Separately Used as Covariates) Results on Reaction Time on Correct Responses in the Flanker Task Without Distracters

		ANOVA		**ANCOVA S-ANXIETY**		**ANCOVA T-ANXIETY**		**ANCOVA DEPRESSION**	
		F	η^2_p	***F***	η^2_p	***F***	η^2_p	***F***	η^2_p
Main Effects	**Congruity**	31.202***	0.451	0.041	0.001	3.287	0.084	18.031***	0.334
	Group	0.057	0.001	3.907	0.098	1.211	0.033	0.009	< 0.001
	S-Anxiety			2.051	0.054				
	T-Anxiety					0.029	0.001		
	Depression							0.011	< 0.001
Two-Way Interactions	**Congruity x Group**	1.624	0.041	2.605	0.067	0.805	0.022	2.929	0.075
	Congruity x S-Anxiety			0.855	0.023				
	Group x S-Anxiety			4.223*	0.105				
	Congruity x T-Anxiety					0.518	0.476		
	Group x T-Anxiety					1.372	0.037		
	Congruity x Depression							1.591	0.042
	Group x Depression							0.002	< 0.001
Three-Way Interactions	**Congruity x Group x S-Anxiety**			3.617ǂ	0.091				
	Congruity x Group x T-Anxiety					1.372	0.037		
	Congruity x Group x Depression							1.372	0.037

*p < 0.05, **p < 0.01, ***p < 0.001, ǂ indicates marginal significance

4.3.2. Physiological Results in Experiment 2

Figure 4.12 shows the pupil response time series averaged across participants in each group and each condition in the flanker task in Experiment 2. For each participant and each trial, the value of the initial data point was shifted to zero, as explained in Section 3.7. Therefore the figure shows the average change in pupil size (in millimeters) throughout each condition. For approximately 1 second (data point 50) from the start of the trials, the curves of different groups and conditions do not seem to differ. Between 1 and 2 seconds (data points 50-100), pupil dilation in incongruent trials seem to be greater than congruent trials for both groups.

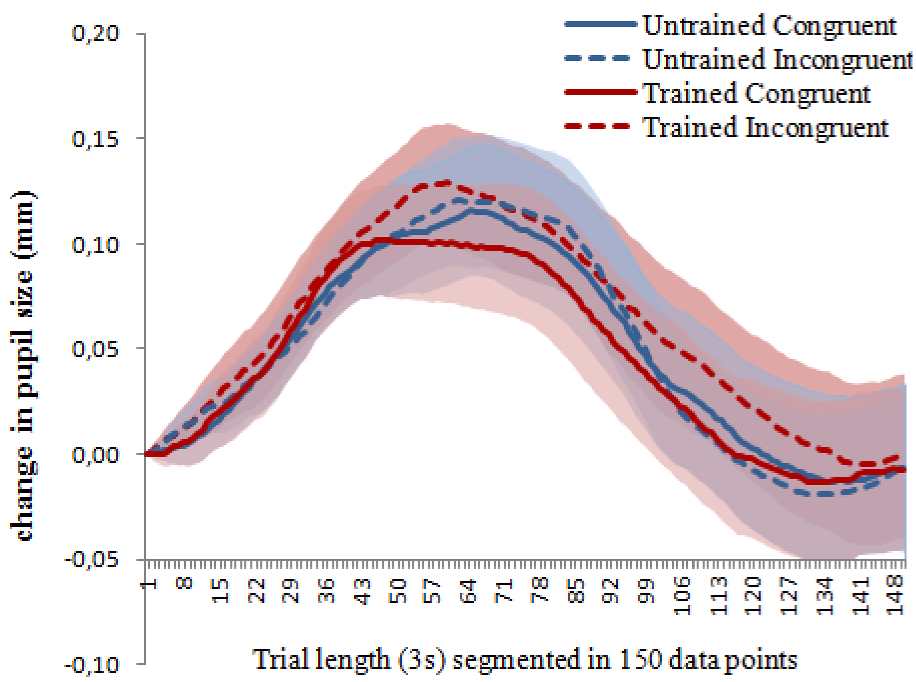


Figure 4.12. Average Time Series for Change in Pupil Size (millimeters)
in Each Condition of the Flanker Task Without Distracters
Upper and Lower Bounds Show ±1 Standard Error

Although there seems to be a specific pattern for the averaged time series graph, this pattern was not supported by a two-way mixed ANOVA with one between-subjects factor of training group (two levels: untrained and trained) and one within-subjects factor of flanker congruity (two levels: congruent and incongruent) conducted for the average change in pupil size (see Table 4.7 and Figure 4.13). The main effect of flanker congruity was not significant, $F(1, 36) = 0.119$, $p = 0.73$, $\eta^2_p = 0.003$, the main effect of training group was not significant, $F(1, 36) = 0.008$, $p = 0.93$, $\eta^2_p < 0.001$, and the interaction between flanker congruity and training group was also not significant, $F(1, 36) = 0.930$, $p = 0.34$, $\eta^2_p = 0.025$.

Table 4.7. Summary of the Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA, for State Anxiety, Trait Anxiety, and Depression Scores Separately Used as Covariates) Results on Average Change in Pupil Size in the Flanker Task Without Distracters

		ANOVA		**ANCOVA S-ANXIETY**		**ANCOVA T-ANXIETY**		**ANCOVA DEPRESSION**	
		F	η^2_p	***F***	η^2_p	***F***	η^2_p	***F***	η^2_p
Main Effects	**Congruity**	0.119	0.003	0.079	0.002	0.035	0.001	0.226	0.007
	Group	0.008	< 0.001	2.506	0.069	7.494*	0.181	6.942*	0.170
	S-Anxiety			1.763	0.049				
	T-Anxiety					0.205	0.006		
	Depression							0.098	0.003
Two-Way Interactions	**Congruity x Group**	0.930	0.025	0.070	0.002	0.832	0.024	1.454	0.041
	Congruity x S-Anxiety			0.130	0.004				
	Group x S-Anxiety			2.600	0.071				
	Congruity x T-Anxiety					0.013	< 0.001		
	Group x T-Anxiety					7.707**	0.185		
	Congruity x Depression							0.134	0.004
	Group x Depression							9.694**	0.222
Three-Way Interactions	**Congruity x Group x S-Anxiety**			0.217	0.006				
	Congruity x Group x T-Anxiety					1.262	0.036		
	Congruity x Group x Depression							0.684	0.414

*p < 0.05, **p < 0.01

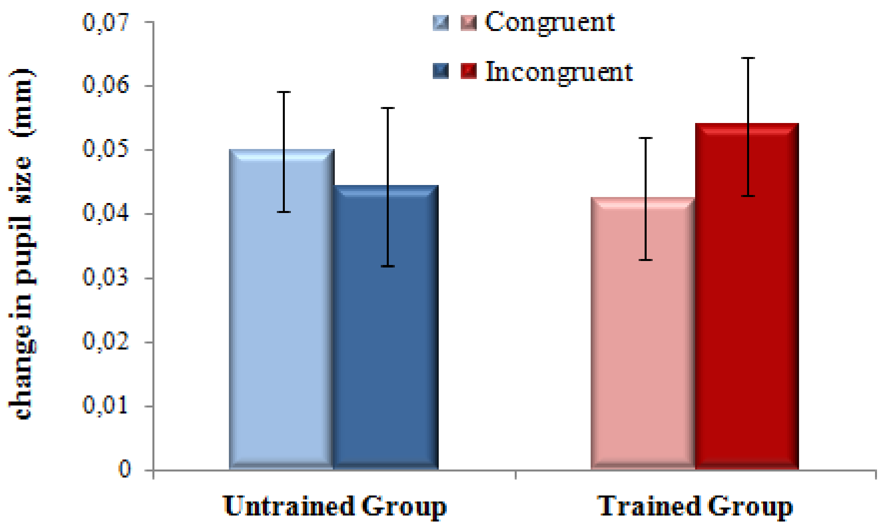


Figure 4.13. Average Change in Pupil Size (millimeters)
Across Flanker Conditions in Experiment 2 for Each Group
Error Bars Show ±1 Standard Error

In Experiment 2 for the pupil dilation measure, three separate two-way mixed ANCOVAs were conducted with the between-subjects factor of training group (two levels: untrained and trained), the within-subjects factor of flanker congruity (two levels: congruent and incongruent) and a covariate (state anxiety score / trait anxiety score / depression score; see Table 4.7). Results revealed that while state anxiety did not interact with the independent variables, trait anxiety significantly interacted with the training group, $F(1, 34) = 7.707$, $p < 0.01$, $\eta^2_p = 0.185$. Trait anxiety score was positively related to pupil dilation for the untrained group, whereas it was negatively related to this measure for the trained group (see Figure 4.14). Depression score also significantly interacted with the training group, $F(1, 34) = 9.694$, $p < 0.01$, $\eta^2_p = 0.222$. As can be seen in Figure 4.15, depression score was positively related to pupil dilation for the untrained group, whereas it was negatively related to this measure for the trained group. The difference in the regression slopes between groups was statistically significant for both congruent trials, $b = 0.006$, $t(34) = 2.064$, $p < 0.05$, and incongruent trials, $b = 0.010$, $t(34) = 2.752$, $p < 0.01$. In addition, the main effect of group became significant after controlling for the effect of depression score, $F(1, 34) = 6.942$, $p < 0.05$, $\eta^2_p = 0.170$ and trait anxiety score, $F(1, 34) = 7.494$, $p < 0.05$, $\eta^2_p = 0.181$.

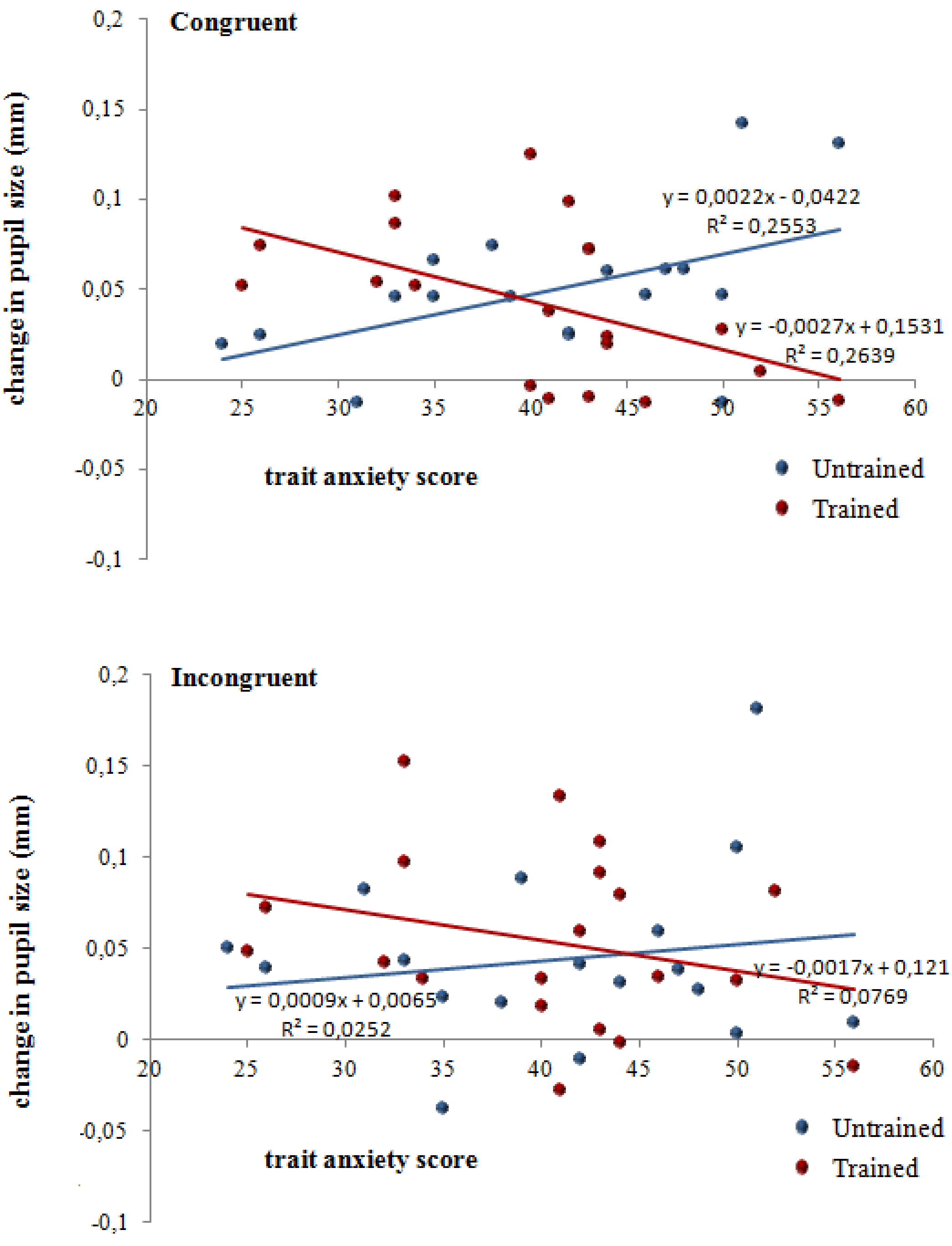


Figure 4.14. Relation Between Trait Anxiety Level and Change in Pupil Size for Each Group Within Each Flanker Condition in Experiment 2

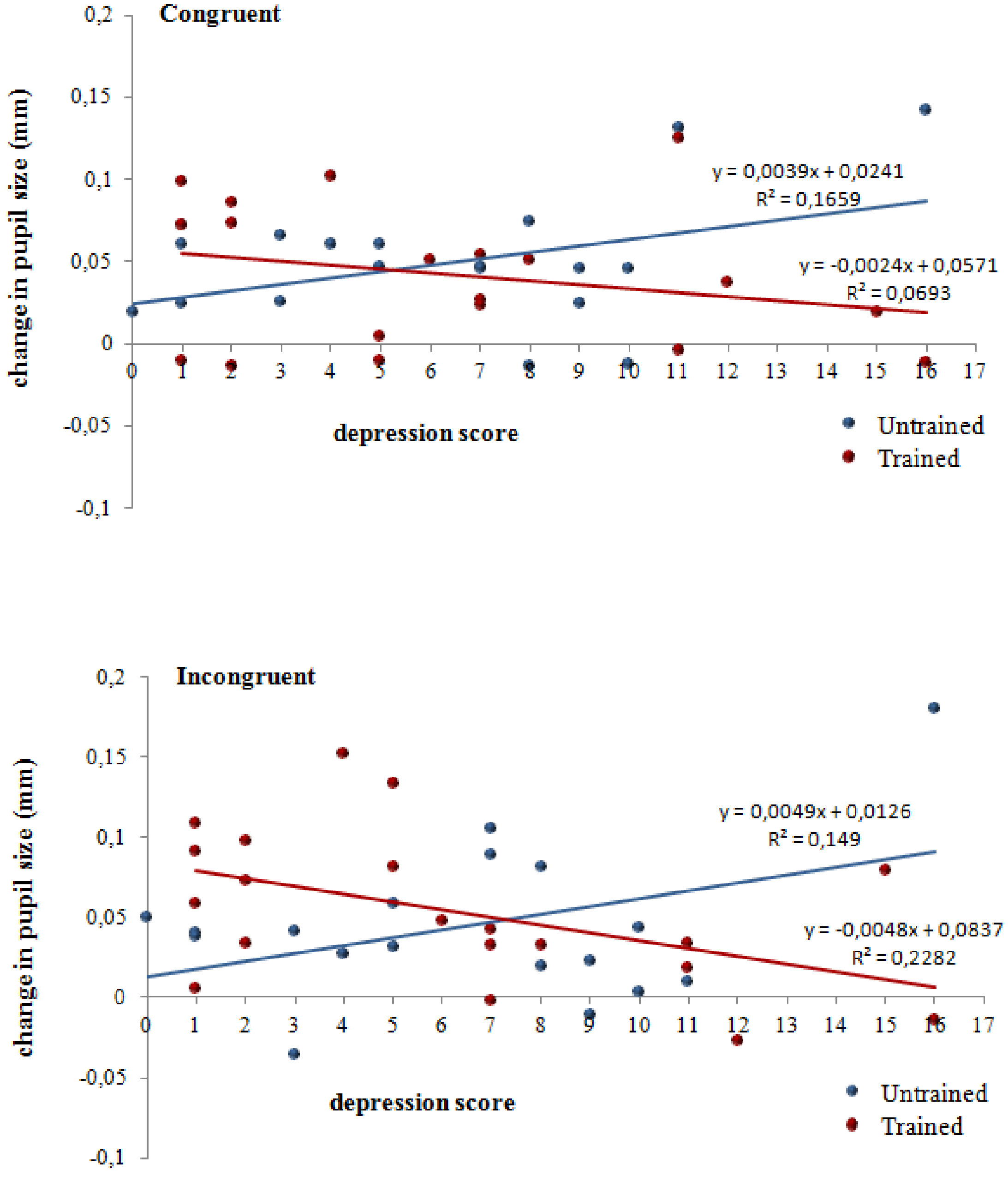


Figure 4.15. Relation Between Depression Level and Pupil Dilation
for Each Group Within Each Flanker Condition in Experiment 2

CHAPTER 5

DISCUSSION

The present dissertation investigated the reciprocal links between emotion and cognition in terms of emotional distraction of cognitive processing and the impact of executive control on emotional processing. Participants completed a conflict resolution task in the presence of neutral and emotional distracters (Experiment 1), after they were either trained on an intense executive control task or completed a simple identification task. They also completed the conflict resolution task without the distracters (Experiment 2), in order to evaluate training-related effects on behavioral and physiological responses during undistracted cognitive performance and assess modulation of mood-related responses by training. The results of the present study, based on behavioral and physiological measurements, were discussed in the following subsections separately for the three phases, namely training and experiments 1 and 2. The findings were presented in relation to hypotheses, predictions and previous studies.

5.1. Training

The aim of the training flanker task with high proportion of incongruent trials (70%) for the trained group was to activate executive control mechanisms. Conflict resolution tasks, such as the one used here, were known to generate conflict, i.e. response competition (Sanders & Lamers, 2002), via incongruent trials and trigger executive control to resolve the conflict (Botvinick et al., 2001; Casey et al., 2000; Hübner & Többel, 2019; MacLeod et al., 2010; Matsumo & Tanaka, 2004). As a control group, the untrained group completed the training flanker task only with congruent trials. Therefore, there were not any conflicts that require executive control for the untrained group.

The accuracy scores in the training session were at ceiling for both groups, which shows that the participants were paying attention to the task. The high accuracy scores came with the cost of significantly prolonged reaction times in incongruent compared to congruent trials for the trained group. This result confirms H1 and shows that training with frequent incongruent trials generated conflict and required mental effort to resolve the conflict as intended, which simply replicates the literature (Cohen et al., 2016).

Pupillary dilation response was smaller in the untrained group compared to the trained group in congruent trials. This result is in accordance with the habituation of pupil response (Marois, Labonte, Parent, & Vachon, 2018; Murphy, Robertson, Balsters, & O'Connell, 2011) and reduced use of working memory resources

(Foroughi, Sibley, & Coyne, 2017) after repeated exposures the the same stimuli. The number of congruent trials for the untrained group (120) was markedly grater than that for the trained group (36). Therefore, the adaptation of pupil response was presumedly higher for the greater number of stimulus repetitions.

Pupil dilation has been associated with increased mental effort (van der Wel & Steenbergen, 2018). In the present study, cognitive load was increased by the incongruent cases for the trained group in the training phase, leading to an anticipation for increased pupil dilation in these trials based on earlier literature (Geva, Zivan, Warsha, & Olchik, 2013; Laeng et al., 2011; Rondeel, van Steenbergen, Holland, & van Knippenberg, 2015). However, on the contrary to H2, the amplitude of pupil dilation did not differ between congruent and incongruent trials for the trained group. An explanation for this outcome can be made considering stimulus probability, which inversely correlates with pupil size (Einhauser, 2017; p.147; Friedman, Hakerem, Sutton, & Fleiss, 1973; Kamp & Donchin, 2014; Qiyuan, Richer, Wagoner, & Beatty, 1985). Pupil dilation was also shown to be a measure of stimulus novelty (Beukema, Jennings, Olson, & Kingdom, 2019). In the present training session, the probabilities of the incongruent and congruent trials were 70% and 30% respectively. Therefore, the effect of rare congruent trials might have neutralized the effect of frequent incongruent trials on the pupil. This explanation can be supported by the observation that the untrained group, who were presented only with congruent trials during the whole training session, exhibited much smaller amplitude of pupil dilation.

5.2. Experiment 1

The aim of the first experiment was to examine the interaction between cognitive load and emotional distraction and to reveal the effect of executive control training on this interaction. In this experiment, the arrow flanker task (50% incongruent trials) with neutral and emotional distracters was completed by both participant groups.

The first line of results in Experiment 1 was based on behavioral emotional distraction. Delayed reaction time in the presence of all emotional pictures compared to neutral ones, was found irrespective of cognitive load and training paradigm. Although ANOVA results did not reveal any interactions between distracter category and other independent variables, after adjusting for state anxiety levels, distracter type interacted with training paradigm and cognitive load. Specifically, when flanker stimuli were congruent, low arousal emotional pictures delayed RTs compared to neutral pictures for both groups. When flanker stimuli were incongruent, performance did not differ between distracter categories for the trained group, but positive arousing distracters delayed RTs compared to neutral ones for the untrained group, partially confirming H3. The results obtained for the untrained group replicate previous studies that showed arousal-related distraction in demanding conditions (Gu et al., 2013; Hart et al., 2010; Jasinska et al., 2012; Melcher et al., 2011). This common finding can be explained in terms of dual competition model, which states that highly arousing task-irrelevant emotional stimuli occupy executive resources needed for effortful tasks, therefore impairs performance on cognitively demanding tasks (Pessoa, 2017, pp.398-400). For the untrained group, delayed latencies for incongruent trials in the presence of arousing pictures also confirms the attentional load theory, which predicts increased emotional distraction during high cognitive load (Lavie, 2005; Lavie et al., 2004). In the present study, the absence of arousal-induced distraction in negative context suggests that the distracter stimuli should be chosen carefully considering both emotional dimensions, as previous studies attributed presumably arousal-induced behavioral impairment to negative valence (Hart et al., 2010; Kalanthroff et al., 2013; Mitchell et al., 2008; Müller et al., 2008; Nikolla et al., 2018; Wessa et al., 2013).

Besides the extensive body of evidence on the impairing effect of emotion on cognitive processing (see Berggren & Derakshan, 2018, p.199; Mueller, 2011 for reviews), a relatively new line of research emphasizes the attenuating effect of regulatory processes on emotion (see Rothermund & Koole, 2018 for a chronological review). The latter conclusions mostly depend on the findings that emotional distraction was decreased or disappeared as control-related operations were triggered by increasing cognitive load (Blair et al., 2007; Cohen et al., 2011, 2012, 2015; Grützmann, Riesel, Kaufmann, Kathmann, & Heinzel, 2019; Papazacharias et al., 2015; Pessoa et al., 2005; Van Dillen et al., 2009). In the present study, the results obtained for the trained group that incongruent condition eliminated emotional distraction is in line with top-down control accounts. This finding also has important implications on the transfer effect of executive training to emotional distraction. The training task included non-emotional, high-frequent conflict resolution for the trained group. Accordingly, performance on conflict resolution was not differentially affected by neutral or emotional distracters. This pattern shows that when a demanding cognitive task was trained, resistance to emotional distraction can be provided at least on the trained task.

The second line of results in Experiment 1 was based on the behavioral interference effect (RT incongruent > RT congruent). The interference effect is a predefined characteristic of conflict resolution tasks (Eriksen & Eriksen, 1974; Stroop, 1935). This outcome has been constantly observed for the flanker task (Brunetti, Zappasodi, Croce, & Di Matteo, 2019; Mansfield, van der Molen, Falkenstein, & van Boxtel, 2013). Moreover, flanker interference was observed after training with over 1500 trials (Chen, Tang, & Chen, 2013). Results of another study suggested that flanker interference endured after six days of training (Cohen et al., 2016). In the present study, the robustness of the behavioral interference was supported by the significant main effect of flanker congruity in Experiment 1. Although ANOVA results did not reveal any interactions between congruity and other independent variables, after adjusting for state anxiety levels, cognitive load interacted with training group and distracter type. In other words, the emergence of the interference effect was influenced by the training paradigm and distracter manipulation. For the trained group, the typical RT interference effect was observed in the neutral (lowest arousal) distracter condition, but it was eliminated in the presence of all distracters with any emotional value. On the other hand, for the untrained group, the interference effect was observed only in the presence of emotional distracters with highest arousal, confirming H4. This pattern implies that without executive control training arousal-related distraction persists.

The third line of the present analyses taking individual differences in state anxiety into account has important implications on emotion regulation mechanisms. The results demonstrated that increasing levels of state anxiety were associated with slower RTs in incongruent trials with negative high arousal distracters for the untrained group, consistently with H5. This indicates that without executive control training, conflict resolution performance in the presence of negative arousing distracters was compromised and this was related to state anxiety levels. Impaired conflict resolution performance in anxiety has been repeatedly shown (Basten et al., 2011; Bishop, 2009; Morgenroth et al., 2019). There is also evidence showing that worry was associated with inefficient attentional control on cognitive tasks that are combined with fear-related emotional distraction (Barker et al., 2018). The present results supported these previous studies and also revealed that state anxiety - RT relation was significantly reversed for the trained group; increasing levels of state anxiety were associated with faster RTs in incongruent trials with negative high arousal distracters. This suggests that executive control training can be beneficial to state-anxiety-related behavioral deficits in dealing with cognitively demanding operations during negative, high-arousal emotional distraction. The absence of trait anxiety- or depression-related effects on RT suggests that while transient anxious mood impair cognitive performance, more permanent mood characteristics might have a mechanism to adapt to reveal intact behavioral performance.

The forth line of results in Experiment 1 shows that in negative high arousal condition, the untrained group demonstrated a reduced RT interference following incongruent trials compared to congruent trials, which is compatible with conflict adaptation accounts (Ullsperger et al., 2005). This was contrary to the predictions in H6. The conflict adaptation effect in the untrained group fits into the model of conflict monitoring theory, which proposes a mechanism which consolidates cognitive control resources for the resolution of upcoming conflicts (Botvinick, Braver, Barch, Carter, & Cohen, 2001). However, due to marginal significance, this result should be interpreted with caution. Conversely, the trained group significantly demonstrated the opposite pattern in the same distracter category. Compared to the preceding incongruent trials, preceding congruent trials substantially reduced the interference effect in the current trial with arousing negative distracters. This is compatible with expectancy accounts (Jimenez & Mendez, 2013). Specifically, when a congruent trial was confronted, especially after a series of congruent trials, the observer would expect an alternation (incongruent stimuli) in the next trial. This is particularly plausible for the trained group, who completed a conflict resolution task with highly frequent incongruent trials in the training. Therefore, these results suggest that expectancies can predominate proactive control mechanisms more strongly than conflict monitoring. Additionally, both the conflict adaptation effect in the untrained group and the inverse effect in the trained group were evident in trials with negative arousing distracters. Padmala and colleagues (2011) investigated the influence of task-irrelevant emotional pictures on conflict adaptation effect and found that the effect was reduced for negative arousing distracters, contrary to the present results. The present finding implies increased control (either conflict-driven or expectancy-driven) in the presence of negative arousing stimuli, which is in line with affect regulation accounts of conflict adaptation (van Steenbergen et al., 2010).

The fifth line of results in Experiment 1 was based on the physiological correlates of conflict resolution in the presence of emotional distracters. First of all, the interference effect was not observed in pupil responses, indirectly disconfirming H8. Despite the presence of behavioral interference effects, the absence of pupillary interference effects is contradictory to the mental effort accounts, since effortful conditions have been associated with greater pupil dilation (van der Wel & Steenbergen, 2018). This pattern has been reported previously (Critchley, Tang, Glaser, Butterworth, & Dolan, 2005) and suggested to imply that conflict and non-conflict cases have similar arousal levels (Schacht, Dimigen, & Sommer, 2010). Unlike flanker congruity, the effect of emotional distracters on pupil dilation was evident in the present results. In Experiment 1, the training groups differed from each other exclusively in trials with negative arousing background pictures. The trained group showed smaller pupil dilation compared to the untrained group for this category, partially confirming H7. Recent studies demonstrated that non-emotional working memory training increased parasympathetic activity during down-regulation of emotional response to negative videos (Xiu et al., 2016) and reduced late positive potential amplitude during reappraisal of negative videos (Xiu, Wu, Chang, & Zhou, 2018). Moreover, non-emotional executive training was found to reduce amygdala response to task-irrelevant negative pictures (Cohen et al., 2016). The present study contributes to this emerging research area by adding the evidence of attenuated pupillary responses to negative high arousal distracters after executive control training. This finding, combined with the association between reduced pupil response to negative stimuli and regulatory processes (Bebko et al., 2011; Cohen et al., 2015), is important for understanding the specific cognitive mechanisms underlying emotion regulation. It is well established that executive functions play a critical role in emotion regulation. However, the involvement of specific components of executive function, namely updating, shifting and inhibition (Miyake et al., 2000), in emotion regulation is still a matter of debate. While some studies emphasized the role of working memory updating (Hendricks & Buchanan, 2016; Levens & Gotlib, 2010; Yoon, LeMoult, & Joorman, 2014), others underlined the role of inhibitory control (Bartholormew, Heller, & Miller, 2019; Joorman & Gotlib, 2010) or shifting (De Lissnyder et al., 2012). The present study suggests that inhibition might be a key mechanism for emotion regulation. Although executive functions have been associated with emotion regulation, it is still unknown whether emotion dysregulation is grounded on a general impairment in these functions or impaired control over emotional stimuli. To this end, using a non-emotional cognitive control training paradigm and demonstrating transfer effects to emotional domain is particularly important for clinical utilization of purely cognitive paradigms.

5.3. Experiment 2

The aim of the second experiment was to evaluate the influence of training on conflict resolution without distraction. A typical behavioral interference effect (RT incongruent > RT congruent) was observed for both groups in the flanker task, partially confirming H9. Contrary to predictions, this effect was equivalent in the two groups; not reduced for the trained group. This result verifies that the interference effect is almost a default for conflict resolution tasks (Brunetti et al., 2019; Eriksen & Eriksen, 1974; Mansfield et al., 2013) and the absence of the effect in some conditions in Experiment 1 was dependent on the type of distracters and training.

Behavioral analyses in the second experiment also indicated that state anxiety level was differentially related to RT for the two training groups, consistently with H11. In conflict trials, there was a positive relationship between state anxiety level and RT for the untrained group. For the same trials, the relationship was negative for the trained group. Anxiety-related behavioral impairment was previously demonstrated in cognitively demanding tasks (Basten et al., 2011). Using a purely cognitive task, the second experiment of the present study supports the accounts of general anxiety-related difficulty in attention-demanding cognitive tasks (Tempesta et al., 2013; Yang et al., 2015), apart from attentional bias to threat (Bar-Haim et al., 2007; Bishop et al., 2004; Morrison & Heimberg, 2013; Yiend & Mathews, 2001).

Physiological interference effect was not observed for any of the groups in the flanker task, disconfirming H10. In the first experiment, an emotional effect was observed in the pupil dilation data, but not an effect of cognitive load. Similarly, pupil size was not influenced by conflict occurrence in the second experiment. One explanation for this result could be fatigue effect, which was shown to decrease stimulus-evoked pupil dilation (Hopstaken et al., 2015). The second experiment was preceded by a psychometric evaluation, a training session, and Experiment 1, which might have increased participants' mental fatigue and influenced pupil dilation amplitudes. Alternatively, the procedure of the second experiment might have prevented the observation of pupillary effects. In a previous study, pupillary interference effects (PD incongruent > PD congruent) were found for both Flanker and Stroop tasks for long (4000ms) or shorter (1100, 1000 and 800ms) inter-trial-intervals, however the amplitudes of pupil dilation and interference effect were smaller for shorter intervals (van Steenbergen et al., 2015). In the second experiment of the present study, there were no intervals between trials, which might have eliminated the difference in pupil response to congruent and incongruent trials. Nevertheless, despite of strong behavioral effects, null results in pupil dilation in response to cognitive conflict challenges the interpretation of physiological reactions to mental effort (van der Wel & Steenbergen, 2018).

As in the behavioral results, mood scores were differentially related to pupil dilation for the two groups. There was a positive relationship between depression levels and pupil size for the untrained group. This relationship was negative for the trained group, consistently with H11. In other words, while increased levels of depressive mood were associated with increased levels of pupil dilation without executive control training, increased levels of depressive mood were associated with decreased levels of pupil dilation after executive control training. Cognitive dysfunction is a core characteristic of depression (McIntyre et al., 2013). However, the cognitive dysfunction is whether specific to processing of emotional inputs or general in control-related processing remains unanswered. For the untrained group in the present study, an increase in pupil dilation as a function of depression score was found in a cognitive task in the absence of any emotional content, suggesting a general depression-related cognitive dysfunction. Importantly, the results indicated a decrease in pupil dilation as a function of depression score for the trained group. This shows the potential for non-emotional executive control training in down-regulation of physiological response to purely cognitive tasks. Increased pupil size previously was linked to increased cognitive efforts during active emotion regulation (Kinner et al., 2017). The present results implied that this pattern for regulating external stimuli might apply to regulating internal states in the absence of cognitive interventions. It is worth to note that sustained effects of executive training were observed in Experiment 2, in spite of the employment of a compelling task with irrelevant emotional items (Experiment 1) between the training session and Experiment 2.

5.4. Limitations of the Present Study

The first and the most important limitation of the present study is the absence of pre-training behavioral and physiological measures of conflict resolution and emotional distraction. This has prevented the author to compare pre-training and post-training measures and specify within-group changes related to the training. The absence of pre-training data also restrains the comparison of post-training data to a true baseline. Despite Experiement 2 provided some insight for undistracted conflict resolution, the preceding phases limit to regard it as a baseline, since the trained group already practised two sessions of conflict resolution and the untrained group also dealt with conflict resolution in Experiment 1. However, eliminating pre-training conflict resolution served the primary aim, which was to implement the distracted cognitive task without any prior demanding tasks for the untrained group. For the same purpose, the phases were implemented in the same order (Training, Experiment 1 and Experiment 2), which might have an affect on the results. Moreover, it was not assured that the two groups did not have pre-training differences in concerned measures. Nevertheless, the groups were well-matched in terms of demographic and psychometric features, which was sufficient to assume pre-training equivalency between groups.

Similarly, the absence of post-test mood measurements hinders the ability to comment on the effects of training on symptom reduction and combine these effects with modulation of mood-related responses. Moreover, despite interpreting the results in a clinical context, healthy participants took part in the study. Future studies are needed to include clinically anxious and depressed participants in order to strengthen the effects of non-emotional training on emotion regulation pathologies.

Another limitation is the absence of subjective valence and arousal ratings for neutral and emotional distracters. The pictures were chosen and categorized according to their normative valence and arousal ratings in the IAPS. Despite this, the IAPS database is very commonly used in literature, especially in emotional distraction studies. This provides a standard while referring to similar studies using the same database.

A forth limitation is that using the flanker task in training and subsequent experiments restricts the results to yield transfer effects to emotional distraction and conflict resolution on the same task. For further generalizations, emotional distraction and cognitive performance should be examined on a different task than the one used in training, such as the Stroop task, which would test a near transfer and a reasoning task which would test a far transfer. In the present study, even though the visual properties of the stimuli and congruity proportions were different in training and experiment 1, they were both flanker tasks. Therefore, it can only affirm transfer of training to eliminating emotional distraction on the same task.

A larger sample size could have strengthened marginally significant results on the behavioral measure of the interaction between flanker congruity, training group, and state anxiety in Experiment 2 and also the marginal significance of the interaction between training group, distracter category and congruity in the analysis of conflict adaptation effect in Experiment 1.

Finally, an analysis of eye movements was not included in the present results, because eye movement patterns were not directly related to the current hypotheses. However, it might indirectly affect pupil size. These indirect effects are two-fold. First, when the eyes move, the eye-tracker measures the pupil size form a different angle, which might induce pseudo changes in pupil diameter. Although the participants were instructed to fixate on and respond to the middle arrow in Experiment 1, there was enough time after the response (~2 s) to make saccades or fixate on a different location in the display. Therefore, implementing a fixation training before conducting the experiment or controlling for the eye movement patterns in data analysis could overcome this limitation. Second, oculomotor control is an effortful process involving the function of cortical and subcortical brain areas (Pare & Wurtz, 2001; Schall & Thompson, 1999) and changes in gaze location might induce systematic changes in pupil size (Gagl, Hawelka, & Hutzler 2011). However, temporal and spatial differences between emotional and neutral stimuli in terms of oculomotor behavior were observed when the tasks require overt processing of stimulus content (Mulckhuyse, 2018). Since the task in the present study includes covert emotional/neutral processing of the pictures, it's reasonable to assume equivalency between distracter categories in terms of eye movements, even if they were present.

CHAPTER 6

CONCLUSION

The primary aim of the present study was to investigate the behavioral and physiological correlates of cognitive conflict resolution with (Experiment 1) and without (Experiment 2) distraction, focusing on the role of non-emotional executive control training. While evaluating the relationship between cognitive load and task-irrelevant stimuli, the influence of emotional dimensions on distraction of ongoing cognitive task was taken into account. An important objective of the present design was to reveal the modulation of the relationship between anxiety / depression states and cognitive / emotional processing by executive control training.

The behavioral results in the emotional distraction experiment (Experiment 1) revealed RT impairment by all emotional content, irrespective of the training paradigm and cognitive load. Furthermore, when the levels of state anxiety were adjusted, behavioral emotional distraction was observed in the presence of low arousal emotional pictures for both training groups within low cognitive load. Within high load, behavioral emotional distraction was observed in the presence of positive high arousal pictures for the untrained group; it was eliminated for the trained group. These findings contribute to the understanding of specific circumstances that cause emotional distraction and that block off the distraction. In addition, behavioral interference effect was observed in the presence of neutral distracters and eliminated in the presence of all emotional distracters after executive control training. Behavioral interference was observed only in the presence of positive high arousal distracters after simple identification training. The evidence for the interference effect in the presence of positive arousing stimuli draws attention to the role of arousal, rather than negative valence, in distracting cognitive function.

State anxiety was related to impaired behavioral performance on conflict resolution in the presence of negative arousing distracters after simple identification training; this effect disapperad after cognitive control training. This suggests that executive control training can neutralize state-anxiety-related effects on behavioral responses in cognitively demanding operations (Experiment 2) and also do so in the presence of negative high-arousal emotional distraction (Experiment 1).

The physiological results in the emotional distraction experiment (Experiment 1) revealed that non-emotional executive control training can reduce pupillary responses to negative arousing distracters, which has important implications on underlying mechanisms of emotion regulation. A cognitive training paradigm down-regulated pupil responses to aversive content, irrespective of the cognitive load of the main task. These findings posit a short, easily administered, and promising non-emotional inhibition paradigm to deal with emotion dysregulation.

The sustained effects of executive control training were observed on the conflict resolution task without distracters (Experiment 2). For the untrained group, increasing levels of pupillary responses as a function of higher depression scores were found in both conflict and non-conflict situations without behavioral gains. This relationship was reversed after cognitive control training. These results clearly indicate that individuals with higher levels of depression benefited from executive control training. Importantly, executive training down-regulated mood-related pupil responses to purely cognitive task components. Just oppositely to the reaction time results, more chronic mood states affected pupil dilation patterns instead of transient mood.

In summary, the present dissertation demonstrated the potential for executive control training in modulating behavioral and physiological correlates of emotional distraction and also in reversing mood-related behavioral and physiological responses to cognitive and task-irrelevant emotional components of an ongoing task.

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APPENDICES

APPENDIX A: INFORMED CONSENT FORM

BİLGİLENDİRİLMİŞ GÖNÜLLÜ KATILIM FORMU

Araştırmanın adı: Dikkat İçerikli Görevler Sırasında Gözbebeği Yanıtının İncelenmesi

Sorumlu araştırmacı: Yard. Doç. Dr. Didem Gökçay

Araştırmanın yapılacağı yer: Ulusal Magnetik Rezonans Araştırma Merkezi (UMRAM) Göz-İzleme Laboratuvarı, Aysel Sabuncu Beyin Araştırmaları Merkezi, Bilkent

Orta Doğu Teknik Üniversitesi Enformatik Enstitüsü Bilişsel Bilimler bölümü doktora öğrencisi Şeyma Koç Yılmaz tarafından, Orta Doğu Teknik Üniversitesi Enformatik Enstitüsü Tıp Bilişimi Bölümü Öğretim Üyelerinden Yrd. Doç. Dr. Didem Gökçay'ın danışmanlığında, doktora tezi kapsamında, dikkat gerektiren görevler sırasında gözbebeği ölçümlerini değerlendirmek için planlanan bu araştırma projesine katılmak için davet edilmektesiniz. Çalışma sadece yetişkinleri kapsamaktadır.

Göz-İzleme, Bilkent Üniversitesi UMRAM Göz-İzleme Laboratuvarı'nda bulunan ve gözbebeği boyutunu ölçmeye yarayan Göz-İzleme cihazı yardımıyla yapılacaktır ve herhangi bir potansiyel risk içermemektedir. Katılımcılardan, oturur pozisyonda, bilgisayar ekranında gösterilen görsellere yanıt vermeleri istenmektedir. Göz-İzleme cihazı bu bilgisayara bağlı olup, vücuda herhangi bir aparatın yerleştirilmesi gerekmemektedir. Göz-İzleme, zararsız bir işlemdir.

Deneyde, bilgisayar ekranı gözünüzün yaklaşık 60 cm uzağında bulunacak ve ekranda gösterilen uyaranları değerlendirmeniz ve klavyenin ilgili tuşlarına basarak cevap vermeniz istenecektir.

Deney üç aşamadan oluşmaktadır.

1. Aşama: Deneyin ilk kısmında, ekranda yukarı veya aşağıyı işaret eden beş adet ok gösterilecektir. Sizden, ortadaki okun aşağı veya yukarı dönük olduğu kararınıza göre cevap düğmelerine basmanız istenecektir.

2. Aşama: Deneyin ikinci kısmında, ekranda sağ veya solu işaret eden beş adet ok, bazı resimler üzerinde gösterilecektir. Sizden ortadaki okun sağa veya sola dönük olduğu kararınıza göre cevap düğmelerine basmanız istenecektir. Resimler herhangi bir cevap gerektirmemektedir.

3. Aşama: Deneyin ücüncü kısmında ise sağ veya sola dönük oklar, resimler olmadan gösterilecek ve yine ortadaki okun sağa veya sola dönük olduğu kararınıza göre cevap düğmelerine basmanız istenecektir. Bu uygulama yaklaşık 30 dk sürecektir.

Bu çalışmada hakkınızda edinilen tüm bilgiler gizli tutulacak ve sadece araştırmacıların bilgisine sunulacaktır. Bu çalışmadan herhangi bir rapor veya yayın yapılması halinde okuyucuların sizleri tanımasına yol açacak hiçbir kişisel bilgi bulunmayacaktır.

Deney, genel olarak rahatsızlık verecek unsurlar içermemektedir. Ancak, katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz, deneyi yarıda bırakıp çıkmakta serbestsiniz. Araştırmaya katılımınız tamamıyla gönüllülük çerçevesinde olup, istediğiniz zaman, hiçbir yaptırım veya cezaya maruz kalmadan, hiçbir hak kaybetmeksizin araştırmadan çekilebilirsiniz. Çalışmaya katılmamayı da seçebilirsiniz.

Deney sonunda, çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için veya herhangi bir sorunuz olduğunda, ODTÜ Enformatik Enstitüsü Bilişsel Bilimler Bölümü doktora öğrencisi Şeyma Koç Yılmaz (Tel: 05058071086, E-posta: seyma.koc@metu.edu.tr) ya da ODTÜ Enformatik Enstitüsü Tıp Bilişimi Bölümü Öğretim Üyesi Yrd. Doç. Dr. Didem Gökçay (Oda: A-216, Tel: 03122103750, E-posta: didemgokcay@ii.metu.edu.tr) ile iletişim kurabilirsiniz.

Bilgilendirilmiş Gönüllü Katılım Formu'ndaki tüm açıklamaları okudum. Yukarıda konusu ve amacı belirtilen araştırma ile ilgili tüm yazılı ve sözlü açıklama aşağıda adı belirtilen araştırmacı tarafından yapıldı. Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman gerekçeli veya gerekçesiz olarak yarıda kesip çıkabileceğimi veya kendi isteğime bakılmaksızın araştırmacı tarafından araştırma dışı bırakılabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayınlarda isim bilgilerim olmadan kullanılmasını, gözbebeği verisi kayıtlarıma sadece araştırmacı veya etik kurul tarafından gizli tutulmak kaydıyla

erişilebilmesini kabul ediyorum. Kendi özgür irademle, hiçbir baskı ve zorlama olmadan "Dikkat İçerikli Görevler Sırasında Gözbebeği Yanıtının İncelenmesi" adlı çalışmaya katılmayı kabul ettiğimi ve bu formun bir kopyasının bana verildiğini aşağıdaki imzamla beyan ederim.

Gönüllü:

Adı Soyadı: Tarih İmza

----/----/-----

Adres ve telefon:

Tanıklık Eden Yardımcı Araştırmacı:

Adı Soyadı: Tarih İmza

----/----/----

APPENDIX B: ETHICAL APPROVAL

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ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

Sayı: 28620816 / 572

15 ARALIK 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Yrd.Doç.Dr. Didem GÖKÇAY ;

Danışmanlığını yaptığınız doktora öğrencisi Şeyma KOÇ YILMAZ'ın **"Dikkat İçerikli Görevler Sırasında Gözbebeği Yanıtının İncelenmesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-FEN-063** protokol numarası ile **15.12.2017-30.07.2018** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Yrd. Doç. Dr. Pınar KAYGAN
Üye

Yrd. Doç. Dr. Emre SELÇUK
Üye

APPENDIX C: DEMOGRAPHIC INFORMATION QUESTIONNAIRE

Kişisel Bilgiler

Adınız-Soyadınız: ________________________________

İletişim Bilgisi (E-posta/Telefon): ______________________________

Yaşınız: ___________

Cinsiyetiniz: ( ) Kadın ( ) Erkek

Medeni Haliniz: ( ) Evli ( ) Bekar

Eğitim durumunuz (Lütfen en son mezun olduğunuz seçeneği işaretleyiniz)?

( ) İlkokul ( ) Ortaokul ( ) Lise ( ) Üniversite ( ) Lisansüstü

Şu an çalıştığımız bir işiniz var mı? ( ) Evet ( ) Hayır

Mesleğiniz nedir? ________________________

Ağılıklı olarak hangi elinizi kullanırsınız? ( ) Sağ ( ) Sol

Sağlık Durumuna İlişkin Bilgiler:

Görme bozukluğunuz var mı? ( ) Var ( ) Yok

Görme bozukluğu varsa hangisi? ( ) Miyop ( ) Astigmat ( ) Hipermetrop

Görme bozukluğu varsa düzeltilmiş mi (gözlük, lazer tedavisi vb. ile)?

( ) Evet ( ) Hayır

Renk körlüğünüz var mı? ( ) Var ( ) Yok

Şu an kullanmakta olduğunuz ilaç(lar) var mı? Varsa ilacın/ilaçların adını belirtiniz.

( ) Var ____

( ) Yok

Psikiyatrik ilaç (antidepresan, antipsikotik gibi) kullanıyorsanız süresini belirtiniz:

( ) 1 aydan daha kısa süredir

( ) 2 aydan daha kısa süredir

( ) 2 aydan daha uzun süredir

Nörolojik bir hastalığınız var mı? Varsa hastalığın adını belirtiniz:

( ) Var _________________________________ ( ) Yok

APPENDIX D: ADAPTED TURKISH VERSION OF BECK DEPRESSION INVENTORY

Aşağıda, kişilerin ruh durumlarını ifade ederken kullandıkları bazı cümleler verilmiştir. Her madde, bir çeşit ruh durumunu anlatmaktadır. Her maddede o duygu durumunun derecesini belirleyen 4 seçenek vardır. Lütfen bu seçenekleri dikkatlice okuyunuz. Son bir hafta içindeki (şu an dahil) duygu durumunuzu göz önünde bulundurarak, size uygun olan ifadeyi bulunuz. Daha sonra, o madde numarasının altında, size uygun ifadeye karşılık gelen seçeneği işaretleyiniz.

1.
( ) Kendimi üzgün hissetmiyorum.
( ) Kendimi üzgün hissediyorum.
( ) Her zaman için üzgünüm ve kendimi bu duygudan kurtaramıyorum.
( ) Öylesine üzgün ve mutsuzum ki dayanamıyorum.

2.
( ) Gelecekten umutsuz değilim.
( ) Geleceğe biraz umutsuz bakıyorum.
( ) Gelecekten beklediğim hiçbir şey yok.
( ) Benim için bir gelecek yok ve bu durum düzelmeyecek.

3.
( ) Kendimi başarısız görmüyorum.
( ) Çevremdeki birçok kişiden daha fazla başarısızlıklarım oldu sayılır.
( ) Geriye dönüp baktığımda, çok fazla başarısızlığımın olduğunu görüyorum.
( ) Kendimi tümüyle başarısız bir insan olarak görüyorum.

4.
( ) Herşeyden eskisi kadar zevk alabiliyorum.
( ) Herşeyden eskisi kadar zevk alamıyorum.
( ) Artık hiçbirşeyden gerçek bir zevk alamıyorum.
( ) Bana zevk veren hiçbir şey yok. Herşey çok sıkıcı.

5.
( ) Kendimi suçlu hissetmiyorum.
( ) Arada bir kendimi suçlu hissettiğim oluyor.
( ) Kendimi çoğunlukla suçlu hissediyorum.
( ) Kendimi her an için suçlu hissediyorum.

6.
( ) Cezalandırıldığımı düşünmüyorum.
( ) Bazı şeyler için cezalandırılabileceğimi hissediyorum.
( ) Cezalandırılmayı bekliyorum.
( ) Cezalandırıldığımı hissediyorum.

7.
( ) Kendimden hoşnutum.
( ) Kendimden pek hoşnut değilim.
( ) Kendimden hiç hoşlanmıyorum.
( ) Kendimden nefret ediyorum.

8.
( ) Kendimi diğer insanlardan daha kötü görmüyorum.
( ) Kendimi zayıflıklarım ve hatalarım için eleştiriyorum.
( ) Kendimi hatalarım için her zaman suçluyorum.
( ) Her kötü olayda kendimi suçluyorum.

9.
( ) Kendimi öldürmek gibi düşüncelerim yok.
( ) Bazen kendimi öldürmeyi düşünüyorum fakat bunu yapamam.
( ) Kendimi öldürebilmeyi isterdim.
( ) Bir fırsatını bulursam kendimi öldürürdüm.

10.
( ) Her zamankinden daha fazla ağladığımı sanmıyorum.
( ) Eskisine göre şu sıralarda daha fazla ağlıyorum.
( ) Şu sıralar her an ağlıyorum.
( ) Eskiden ağlayabilirdim, ama şu sıralarda istesem de ağlayamıyorum.

11.
( ) Her zamankinden daha sinirli değilim.
( ) Her zamankinden daha kolayca sinirleniyor ve kızıyorum.
( ) Çoğu zaman sinirliyim.
( ) Eskiden sinirlendiğim şeylere bile artık sinirlenemiyorum.

12.
( ) Diğer insanlara karşı ilgimi kaybetmedim.
( ) Eskisine göre insanlarla daha az ilgiliyim.
( ) Diğer insanlara karşı ilgimin çoğunu kaybettim.
( ) Diğer insanlara karşı hiç ilgim kalmadı.

13.
( ) Kararlarımı eskisi kadar kolay ve rahat verebiliyorum.
( ) Şu sıralarda kararlarımı vermeyi erteliyorum.
( ) Kararlarımı vermekte oldukça güçlük çekiyorum.
( ) Artık hiç karar veremiyorum.

14.
( ) Dış görünüşümün eskisinden daha kötü olduğunu sanmıyorum.
( ) Yaşlandığımı ve çekiciliğimi kaybettiğimi düşünüyor ve üzülüyorum.
( ) Dış görünüşümde artık değiştirilmesi mümkün olmayan olumsuz değişiklikler olduğunu hissediyorum.
( ) Çok çirkin olduğumu düşünüyorum.

15.
( ) Eskisi kadar iyi çalışabiliyorum.
( ) Bir işe başlayabilmek için eskisine göre kendimi daha fazla zorlamam gerekiyor.
( ) Hangi iş olursa olsun, yapabilmek için kendimi çok zorluyorum.
( ) Hiçbir iş yapamıyorum.

16.
( ) Eskisi kadar rahat uyuyabiliyorum.
( ) Şu sıralar eskisi kadar rahat uyuyamıyorum.
( ) Eskisine göre 1 veya 2 saat erken uyanıyor ve tekrar uyumakta zorluk çekiyorum.
( ) Eskisine göre çok erken uyanıyor ve tekrar uyuyamıyorum.

17.
( ) Eskisine kıyasla daha çabuk yorulduğumu sanmıyorum.
( ) Eskisinden daha çabuk yoruluyorum.
( ) Şu sıralarda neredeyse herşey beni yoruyor.
( ) Öyle yorgunum ki hiçbirşey yapamıyorum.

18.
( ) Sağlığım beni pek endişelendirmiyor.
( ) Son zamanlarda ağrı, sızı, mide bozukluğu, kabızlık gibi sorunlarım var.
( ) Ağrı, sızı gibi bu sıkıntılarım beni epey endişelendirdiği için başka şeyleri düşünmek zor geliyor.
( ) Bu tür sıkıntılar beni öylesine endişelendiriyor ki, artık başka birşey düşünemiyorum.

19.
( ) İştahım eskisinden pek farklı değil.
( ) İştahım eskisi kadar iyi değil.
( ) Şu sıralarda iştahım epey kötü.
( ) Artık hiç iştahım yok.

20.
( ) Son zamanlarda cinsel yaşantımda dikkatimi çeken bişey yok.
( ) Eskisine göre cinsel konularla daha az ilgileniyorum.
( ) Şu sıralarda cinsellikle pek ilgili değilim.
( ) Artık cinsellikle hiçbir ilgim kalmadı.

21.
( ) Son zamanlarda pek fazla kilo kaybettiğimi sanmıyorum.
( ) Son zamanlarda istemediğim halde üç kilodan fazla kaybettim.
( ) Son zamanlarda istemediğim halde beş kilodan fazla kaybettim.
( ) Son zamanlarda istemediğim halde yedi kilodan fazla kaybettim.

APPENDIX E: ADAPTED TURKISH VERSION OF STATE AND TRAIT ANXIETY INVENTORY

Aşağıda kişilerin kendilerine ait duyguları anlatmada kullandıkları bir takım ifadeler verilmiştir. Öncelikle her ifadeyi okuyunuz. Sonra da o ifadeler, sizi hangi seviyede yansıtıyorsa, ifadenin altında verilen ilgili seçeneği işaretleyiniz. Bu soruların doğru ya da yanlış cevabı yoktur. İfadeler üzerinde fazla düşünmemeniz ve o anda kendinizi nasıl hissettiğinizi gösteren cevabı işaretlemeniz gerekmektedir.

1. Şu anda sakinim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

2. Kendimi emniyette hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

3. Şu anda sinirlerim gergin.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

4. Pişmanlık duygusu içindeyim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

5. Şu anda huzur içindeyim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

6. Şu anda hiç keyfim yok.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

7. Başıma geleceklerden endişe ediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

8. Kendimi dinlenmiş hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

9. Şu anda kaygılıyım.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

10. Kendimi rahat hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

11. Kendime güvenim var.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

12. Şu anda asabım bozuk.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

13. Çok sinirliyim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

14. Sinirlerimin çok gergin olduğunu hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

15. Kendimi rahatlamış hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

16. Şu anda halimden memnunum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

17. Şu anda endişeliyim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

18. Heyecandan kendimi şaşkına dönmüş hissediyorum.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

19. Şu anda sevinçliyim.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

20. Şu anda keyfim yerinde.

( ) Hiç
( ) Biraz
( ) Çok
( ) Tamamiyle

Aşağıda kişilerin kendilerine ait duyguları anlatmada kullandıkları bir takım ifadeler verilmiştir. Öncelikle her ifadeyi okuyunuz. Sonra da o ifadeler, sizi hangi seviyede yansıtıyorsa, ifadenin altında verilen ilgili seçeneği işaretleyiniz. Bu soruların doğru ya da yanlış cevabı yoktur. İfadeler üzerinde fazla düşünmemeniz ve genellikle kendinizi nasıl hissettiğinizi gösteren cevabı işaretlemeniz gerekmektedir.

21. Genellikle keyfim yerindedir.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

22. Genellikle çabuk yorulurum.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

23. Genellikle kolay ağlarım.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

24. Başkaları kadar mutlu olmak isterim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

25. Çabuk karar veremediğim için fırsatları kaçırırım.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

26. Kendimi dinlenmiş hissediyorum.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

27. Genellikle sakin, kendine hakim ve soğukkanlıyım.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

28. Güçlüklerin yenemeyeceğim kadar biriktiğini hissederim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

29. Önemsiz şeyler hakkında endişelenirim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

30. Genellikle mutluyum.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

31. Her şeyi ciddiye alır ve endişelenirim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

32. Genellikle kendime güvenim yoktur.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

33. Genellikle kendimi emniyette hissederim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

34. Sıkıntılı ve güç durumlardan kaçınırım.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

35. Genellikle kendimi hüzünlü hissederim.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

36. Genellikle hayatımdan memnunum.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

37. Olur olmaz düşünceler beni rahatsız eder.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

38. Hayal kırıklıklarını öylesine ciddiye alırım ki hiç unutamam.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

39. Aklı başında ve kararlı bir insanım.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

40. Son zamanlarda kafama takılan konular beni tedirgin ediyor.

( ) Hemen hiçbir zaman
( ) Bazen
( ) Çok zaman
( ) Hemen her zaman

APPENDIX F: ADAPTED TURKISH VERSION OF POSITIVE AND NEGATIVE AFFECT SCHEDULE

Aşağıda farklı duygusal durumları niteleyen sözcükler bulunmaktadır. Lütfen her bir sözcüğü okurken kendinizi son bir haftadır nasıl hissettiğinizi, diğer bir deyişle her bir duyguyu ne ölçüde yaşadığınızı düşününüz ve cevabınızı verilen ölçeği kullanarak belirtiniz. Lütfen her ifadeyi dikkatlice okuyunuz ve düşüncenizi en iyi yansıtan seçeneği işaretleyiniz. Düşüncenizi değiştirirseniz başka bir seçeneği işaretleyip değiştirebilirsiniz.

İlgili

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Sıkıntılı

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Heyecanlı

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Mutsuz

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Güçlü

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Suçlu

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Ürkmüş

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Düşmanca

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Hevesli

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Gururlu

( ) Çok az veya hiç
( ) Biraz
( ) Ortalama
( ) Oldukça
( ) Çok fazla

Asabi

( ) Çok az veya hiç
( ) Biraz
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( ) Oldukça
( ) Çok fazla

Uyanık

( ) Çok az veya hiç
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( ) Çok fazla

Utanmış

( ) Çok az veya hiç
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( ) Çok fazla

İlhamlı

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Sinirli

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( ) Çok fazla

Kararlı

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Dikkatli

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( ) Çok fazla

Tedirgin

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( ) Oldukça
( ) Çok fazla

Aktif

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( ) Oldukça
( ) Çok fazla

Korkmuş

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( ) Oldukça
( ) Çok fazla

APPENDIX G: RATING MEANS AND STANDART DEVIATIONS FOR EACH PICTURE WITHIN EACH DISTRACTER CATEGORY

Distracter Category	Image Description	IAPS Number	Valence Mean	Valence SD	Arousal Mean	Arousal SD	Image Set
Neutral	NeuMan	2102	5,16	0,96	3,03	1,87	16\
	Farmer	2191	5,30	1,62	3,61	2,14	14\
	LonelyBoy	2272	4,50	1,78	3,74	1,94	13\
	Boy	2273	5,41	1,55	3,52	1,81	17\
	Reading	2377	5,19	1,31	3,50	1,95	19\
	Couple	2390	5,40	1,18	3,57	1,92	19\
	Girl	2411	5,07	0,85	2,86	1,84	18\
	Shopping	2745,1	5,31	1,08	3,26	1,96	14\
	Chess	2840	4,91	1,52	2,43	1,82	6\
	Coffeecup	7057	5,35	1,37	3,39	2,01	16\
	Truck	7130	4,77	1,03	3,35	1,90	3\
	Airplane	7632	5,22	1,69	4,78	2,36	18\
Positive, High Arousal	Children	2216	7,57	1,31	5,83	2,20	11\
	SkyDivers	5621	7,57	1,42	6,99	1,95	7\
	Windsurfers	5623	7,19	1,44	5,67	2,32	8\
	Skier	8030	7,33	1,76	7,35	2,02	2\
	Skier	8190	8,10	1,39	6,28	2,57	5\
	Beach	5833	8,22	1,08	5,71	2,66	16\
	Sailboat	8170	7,63	1,34	6,12	2,30	6\
	WaterSkier	8200	7,54	1,37	6,35	1,98	3\
	Rafting	8370	7,77	1,29	6,73	2,24	5\
	RollerCoaster	8490	7,20	2,35	6,68	1,97	4\
	WaterSlide	8501	7,58	1,63	5,79	2,26	9\
	Money	8501	7,91	1,66	6,44	2,29	6\
Positive, Low Arousal	Kittens	1463	7,45	1,76	4,79	2,19	8\
	Porpoise	1920	7,90	1,48	4,27	2,53	4\
	Father	2057	7,81	1,28	4,54	2,41	10\
	Baby	2070	8,17	1,46	4,51	2,74	4\
	Girls	2091	7,68	1,43	4,51	2,28	7\
	Father/Child	2151	7,32	1,63	4,37	2,13	19\
	Father	2165	7,63	1,48	4,55	2,55	9\
	Boys	2224	7,24	1,58	4,85	2,11	14\
	Family	2340	8,03	1,26	4,90	2,20	3\
	Boat	2398	7,48	1,32	4,74	2,11	16\
	Couple	2530	7,80	1,55	3,99	2,11	3\
	Seaside	5210	8,03	1,09	4,60	2,48	18\
Negative, High Arousal	DrugAddict	2717	2,58	1,32	5,70	2,16	16\
	War	2683	2,62	1,78	6,21	2,15	13\
	Assault	9428	2,31	1,31	5,66	2,41	15\
	Bomb	9424	2,87	1,62	5,78	2,12	16\
	Soldiers	9163	2,10	1,36	6,53	2,21	19\
	Ship	9600	2,48	1,62	6,46	2,31	5\
	Hunters	2688	2,73	2,07	5,98	2,22	14\
	Assault	9423	2,61	1,51	5,66	2,15	16\
	Injury	3103	2,07	1,27	6,06	2,30	18\
	CarAccident	9901	2,27	1,25	5,70	2,22	15\
	CarAccident	9903	2,36	1,35	5,71	2,28	16\
	Fire	9921	2,04	1,47	6,52	1,94	7\
Negative, Low Arousal	Hospital	2205	1,95	1,58	4,53	2,23	6\
	KidCry	2301	2,78	1,38	4,57	1,96	17\
	CryingFamily	2456	2,84	1,27	4,55	2,16	18\
	CryingBoy	2900,1	2,56	1,41	4,61	2,07	11\
	DisabledChild	3300	2,74	1,56	4,55	2,06	6\
	Mastectomy	9432	2,56	1,66	4,92	2,28	7\
	Smoke	9280	2,80	1,54	4,26	2,44	9\
	HomelessMan	9331	2,87	1,28	3,85	2	10\
	Pollution	9342	2,85	1,41	4,49	1,88	14\
	Handicapped	9415	2,82	2	4,91	2,35	8\
	SickKitty	9561	2,68	1,92	4,79	2,29	10\
	Cigarettes	9830	2,54	1,75	4,86	2,63	6\

APPENDIX H: TABLE A1

Table A1. Summary of picture content in each distracter category (Neut: Neutral, Pos-Hi: Positive High Arousal, Pos-Lo: Positive Low Arousal, Neg-Hi: Negative High Arousal, Neg-Lo: Negative Low Arousal).

	Single person	**2-3 people**	**Crowded**	**Animal(s)**	**Outdoor**	**Indoor**	**Vehicle**	**Salient Object(s)**	**Human Presence Total Pictures**	**Complexity***
Pos-Hi	8200	2216 5623 8190	5621 5833 8030 8370 8490 8496		2216 5621 5623 5833 8030 8170 8190 8200 8370 8490 8496		8170	5623 8030 8190 8200 8370 8490 8496 8501	10/12	30
Pos-Lo	2070	2057 2091 2151 2165 2224 2340 2530	2398	1463 1920 2091	1920 2091 2151 2224 2398 2530 5210	2070 2340	2398	1920 2530	9/12	24
Neut	2102 2191 2273 2377 2745.1 2840	2390 2411	2272 7632		2102 2191 2272 2273 2377 7130	2390 2411 2745.1 2840 7632	7130 7632	2102 2273 2377 2390 2411 2745.1 2840 7057	10/12	31
Neg-Lo	2301 3300 9331 9342 9432	2205 2456 2900.1	9415	9561	2456 9280 9342 9415 9561 9830	2205 3300 9432		2205 3300 9280 9331 9342 9415 9830	9/12	26
Neg-Hi	2688 2717 3103	9921	2683 9163 9423 9424 9428 9903	2688	2683 2688 9163 9423 9424 9428 9600 9901 9903 9921	2717 3103	2688 9600 9901 9903	2683 2688 2717 9163 9423 9424 9921	10/12	34

* Complexity score was calculated as the total number of items in each row. Item codes belong to the pictures. An item may be present in one than one column.

APPENDIX I: DEBRIEFING FORM

Katılım Sonrası Bilgilendirme Formu

Öncelikle araştırmamıza katıldığınız için teşekkür ederiz.

Katıldığınız araştırmanın amacı, duygusal çeldiriciler ve bilişsel kontrol arasındaki ilişkiyi incelemektir. Literatüre göre, olumsuz duygu içeren çeldiriciler, dikkat içeren görevler sırasında performansı düşürmektedir. Bu araştırmada, bilişsel kontrol mekanizmalarını önceden çalıştırmanın bu etkiyi azaltması ve gözbebeği yanıtını değiştirmesi beklenmektedir. Ayrıca, duygu durumunun bu süreçle bağlantısı incelenecektir.

Bu amaçla, deneyden önce sizden duygu durum testlerini doldurmanız istenmiş ve daha sonra laboratuvarda katıldığınız deney sırasında görsel uyaranlara verdiğiniz cevaplarınız ve gözbebeği ölçümleriniz kaydedilmiştir.

Katılımcıların yarısına, deneyin ilk kısmında ekranda aynı yönü (yukarı veya aşağı) gösteren beş ok gösterilmiş ve ortadaki okun yönünü saptamaları istenmiştir. Katılımcıların diğer yarısı içinse, ilk kısımda gösterilen oklardan ortadaki, %70 oranla çevredeki okların aksi yönünü işaret etmiş ve ortadaki okun tersi yönünü saptamaları istenmiştir. Çelişki içeren ikinci grupta, bu çelişkiyi çözmek için bilişsel kontrol mekanizmalarının devreye girmesi söz konusudur.

Deneyin ikinci kısmı, bütün katılımcılar için aynı olup, ekrandaki oklar sağı veya solu işaret etmektedir. Ortadaki okun yönü %50 oranla çevredeki oklarla çelişkilidir. Deneyin bu kısmında, okların bazı resimler üzerinde gösterileceği söylenmiş, ancak bu resimlerin duygusal uyaranlar içerdiği katılımcılara deneyden önce açıklanmamıştır. Deneyin üçüncü ve son kısmında, ikinci kısım, herhangi bir resim içermeden tekrarlanmıştır.

Deneyin ilk kısmında yüksek çelişki içeren gruba dahil olan katılımcıların performansının, ikinci kısımda olumsuz duygu içeren çeldiricilerden, ilk kısımda çelişki içermeyen gruba göre daha az etkilenmesi beklenmektedir.

Bu çalışmadan alınacak ilk verilerin Nisan 2018 sonunda elde edilmesi amaçlanmaktadır. Elde edilen bilgiler sadece bilimsel araştırma ve yazılarda kullanılacaktır. Çalışmanın sağlıklı ilerleyebilmesi ve bulguların güvenilir olması için çalışmaya katılacağını bildiğiniz diğer kişilerle çalışma ile ilgili detaylı bilgi paylaşımında bulunmamanızı rica ederiz. Çalışmamıza katıldığınız için tekrar çok teşekkür ederiz.

Araştırmanın sonuçlarını öğrenmek ya da daha fazla bilgi almak için aşağıdaki isimlere başvurabilirsiniz:

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2012 – **Middle East Technical University, Ankara**
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Expected Degree: PhD
CGPA: 3.88/4

2010 – 2012 **Middle East Technical University, Ankara**
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Degree: M.S.
CGPA: 4.00/4

2005 – 2010 **Bilkent University, Ankara**
Department of Psychology

Degree: B.A.
CGPA: 3.86/4

2001 – 2005 **Bucak Anatolian High School, Burdur**

Degree: High School
CGPA: 4.98/5

SKILLS AND ABILITIES

Computer Microsoft Office (Word, Excel, Access, PowerPoint)
Level: Advanced
SPSS, Minitab (Statistical Analysis Softwares)
Level: Advanced
AFNI (Software for Analysis of Functional MRI Data)
Level: Advanced
Prolog, Matlab
Level: Beginner
Adobe Photoshop
Level: Intermediate

Language Advanced English

Research Workshop in Cognitive Psychology Research, 2007-2008 Fall Semester
Senior Thesis (Behavioral Study on Categorical Color Perception), 2010
Master Thesis (fMRI Study on Categorical Color Perception), 2012
EU Project: MasterMind (Computerized Cognitive Behavioral Therapy), 2015-2017
PhD Thesis (Eye-Tracking Study on Executive Control Training), 2016 - Present

OTHER INFORMATION

Achievements Bilkent University Admission Ceiling Score, 2005
Highest Ranking Student of the Department of Psychology, Bilkent University, 2010
Bilkent University High Honor Certificates, 2006-2010 All Semesters
Graduate Courses Performance Award, METU, 2011

Scholarships Bilkent University Full Scholarship, 2005-2010
Tübitak 2205 Undergraduate Scholarship, 2005-2010
Tübitak 2210 Graduate Scholarship, 2010-2012
Tübitak 2211 Doctorate Scholarship, 2012- Present

Certificates Certificate of Functional Magnetic Resonance Imaging, UMRAM, Ankara, 2010
Certificate of Attendance, EEG Course for Beginners, UMRAM, Ankara, 2018
Certificate of Theoretical Training in Integrative Psychotherapy, Bayramoğlu/Kocaeli, 2014-2015
Certificate of Human Resources Management, Hacettepe University, Ankara, 2019
Certificate of Career Consciousness and Personal Improvement, Bilkent Career Center, 2010
Certificate of Recognition, Bilkent University, School of Applied Technology & Management, Ankara, 2009
Certificate of Taekwondo, Green Belt, 2007

Research Interests Neuropsychology, Neuroimaging
Eye-Tracking, EEG
Experimental Psychology

TEZ İZİN FORMU / THESIS PERMISSION FORM

ENSTİTÜ / INSTITUTE

Fen Bilimleri Enstitüsü / Graduate School of Natural and Applied Sciences ☐

Sosyal Bilimler Enstitüsü / Graduate School of Social Sciences ☐

Uygulamalı Matematik Enstitüsü / Graduate School of Applied Mathematics ☐

Enformatik Enstitüsü / Graduate School of Informatics ☐

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Soyadı / Surname : ....

Adı / Name : ....

Bölümü / Department : ....

TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English) : ....

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TEZİN TÜRÜ / DEGREE**:** **Yüksek Lisans** / Master ☐ **Doktora** / PhD ☐

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