University of Cyprus

DEPARTMENT OF PSYCHOLOGY

EXPLICIT AND IMPLICIT EMOTION REGULATION ABILITY AND ITS LINK TO EXECUTIVE FUNCTIONS: TOWARDS THE DEVELOPMENT OF NOVEL COMPUTERIZED INTERVENTIONS.

DOCTOR OF PHILOSOPHY DISSERTATION

ELENA KOUMI

2021

University of Cyprus

DEPARTMENT OF PSYCHOLOGY

EXPLICIT AND IMPLICIT EMOTION REGULATION ABILITY AND ITS LINK TO EXECUTIVE FUNCTIONS: TOWARDS THE DEVELOPMENT OF NOVEL COMPUTERIZED INTERVENTIONS.

ELENA KOUMI

A Dissertation Submitted to the University of Cyprus in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December, 2021

VALIDATION PAGE

Doctoral Candidate: Elena Koumi

Doctoral Thesis Title: Explicit and Implicit Emotion Regulation Ability and its link to Executive Functions: Towards the development of novel computerized interventions.

The present Doctoral Dissertation was submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy at the ***Department of Psychology*** *and was approved on the 16th of June, 2021 by the members of the* ***Examination Committee****.*

Examination Committee:

Research Supervisor:__Dr. Georgios Spanoudis, Professor, ____________________

(Name, position and signature)

Committee Member:_Dr. Georgia Panayiotou, Professor, ______________________

(Name, position and signature)

Committee Member: Dr. Evangelos Paraskevopoulos, Lecturer__________________

(Name, position and signature)

Committee Member: Dr. Andreas Chatzittofis, Lecturer _______________________

(Name, position and signature)

Committee Member: Dr. Susanne Schweizer, Scientia Senior Lecturer____________

(Name, position and signature)

DECLARATION OF DOCTORAL CANDIDATE

The present doctoral dissertation was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy of the University of Cyprus. It is a product of original work of my own, unless otherwise mentioned through references, notes, or any other statements.

……… Elena Koumi …………..

…………………………………..

ΠΕΡΙΛΗΨΗ [Ελληνικά]

Σύγχρονα ερευνητικά δεδομένα, τεκμηριώνουν τον πυρηνικό ρόλο της Δυσκολίας Ρύθμισης Συναισθημάτων, σ' ένα εύρος μορφών ψυχοπαθολογίας. Η Ικανότητα για Ρύθμιση Συναισθημάτων, ορίζεται από τον Gross (1998), έως προσπάθειες επίδρασης του είδους των συναισθημάτων που βιώνει κάποιος, του χρόνου και της διάρκειας για την οποία τα βιώνει, και του τρόπου με τον οποίο βιώνει ή εκδηλώνει τα συναισθήματα αυτά. Η διαδικασία Ρύθμισης Συναισθημάτων, δύναται να είναι συνειδητή (ενεργοποιείται συνειδητά), ή υποσυνείδητη (πυροδοτείται αυτόματα διαμέσου υποσυνείδητων διεργασιών). Η ικανότητα ρύθμισης συναισθημάτων έχει προταθεί να βασίζεται στις ίδιες εγκεφαλικές δομές και νευρωνικά δίκτυα που εμπλέκονται στην εκτέλεση των επιτελεστικών λειτουργιών. Εντούτοις, προηγούμενες έρευνες που έχουν μελετήσει τη σχέση μεταξύ της Ικανότητας για Ρύθμιση Συναισθημάτων και Επιτελεστικών Λειτουργιών, έχουν αποφέρει ασυνεπή αποτελέσματα. Από την άλλη, η ικανότητα για υποσυνείδητη/αυτόματη ρύθμιση συναισθημάτων, φαίνεται να στηρίζεται σε ένα διακριτό/ξεχωριστό, πλην εν μέρη κοινό, νευρωνικό δίκτυο. Ελλείμματα στην ικανότητα για αυτόματη/υποσυνείδητη, παρά συνειδητή, ρύθμιση συναισθημάτων, φαίνονται να διαδραματίζουν έναν ακόμη πιο κεντρικό ρόλο, σε διάφορες μορφές ψυχοπαθολογίας.

Δεδομένων: (α) των σύγχρονων, και ασυνεπών, ευρημάτων για τη σχέση μεταξύ των επιτελεστικών λειτουργιών και της ικανότητας για ρύθμιση συναισθημάτων, (β)
(γ) του πυρηνικού ρόλου της ρύθμισης, και ιδιαίτερα της υποσυνείδητης ρύθμισης συναισθημάτων στη ψυχοπαθολογία και (γ) την ευρεία ύπαρξη ελλειμμάτων Επιτελεστικών Λειτουργιών σε άτομα που παρουσιάζουν κλινική συμπτωματολογία, στόχος της παρούσας μελέτης είναι η διερεύνηση της σχέσης μεταξύ της Ρύθμισης Συναισθημάτων, των Επιτελεστικών Λειτουργιών και των Συναισθηματικών Διαταραχών, μέσω συμπεριφορικών και ψυχομετρικών μετρήσεων καθώς και μέσα από τη διενέργεια Ηλεκτροεγκαφαλογραφήματος Προκλητών Δυναμικών (ERPs).

Δείγμα: 120 φοιτητές (33 άντρες, 87 γυναίκες, Ηλικία, M=23,54, SD=4,98) στρατολογήθηκαν εθελοντικά, από το Τμήμα Ψυχολογίας του Πανεπιστημίου Κύπρου, συμπεριλαμβανομένων φοιτητών που λαμβάνουν υπηρεσίες από το Κέντρο Ψυχικής Υγείας του Πανεπιστημίου. Εργαλεία ανίχνευσης ψυχοπαθολογίας (συγκεκριμένα, το Ερωτηματολόγιο PDSQ και η κλίμακα αξιολόγηση κλινικών συμπτωμάτων SCL-90-R, χορηγήθηκαν ως εργαλεία αξιολόγησης της συμπτωματολογίας των συναισθηματικών διαταραχών. Οι συμμετέχοντες δεν αποκλείστηκαν από συμμετοχή στην έρευνα, βάσει ενδεχόμενων συμπτωμάτων.

Μετρήσεις: Εφαρμόστηκαν σταθμισμένα συμπεριφορικά έργα για τη μέτρηση της ικανότητας Επιτελεστικών Λειτουργιών και Ρύθμισης Συναισθημάτων (τόσο Συνειδητής, όσο και Υποσυνείδητης/Αυτόματης), ενώ συλλέχθηκαν τόσο συμπεριφορικά, όσο και ηλεκτροφυσιολγιικά δεδομένα, καθώς και δεδομένα μέσω αυτό-αναφοράς.. Πιο συγκεκριμένα, χορηγήθηκαν το έργα από το μοντέλο Επιτελεστικών Λειτουργιών των Miyake et al., (2000), Αναστολή, Μετατόπιση, Ενημέρωση) για τη μέτρηση της Επιτελεστικής Ικανότητας, ενώ ένα κλασσικό έργο ρύθμισης συναισθημάτων (προσαρμογή από Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011) καθώς και ένα έργο Αυτόματης/Ασυνείδητης Ρύθμισης (προσαρμογή από Egner, Active, Gale & Hirsch, 2008), εφαρμόστηκαν για τη μέτρηση της συνειδητής και υποσυνείδητης ρύθμισης συναισθημάτων, αντίστοιχα. Πέρα από τις ψυχομετρικές μετρήσεις ανίχνευσης ενδεχόμενης κλινικής συμπτωματολογίας (PDSQ; SCL-90R), χορηγήθηκαν και το Ερωτηματολόγιο Ρύθμισης Συναισθημάτων (ERQ), καθώς και το ερωτηματολόγιο Δυσκολιών στη Ρύθμιση Συναισθημάτων (DERS), ως ψυχομετρικά εργαλεία αξιολόγησης της ικανότητας Ρύθμισης. Οι αλλαγές στο πλάτος του LPP αξιοποιήθηκαν ως ηλεκτροφυσιολική μέτρηση τόσο της συνειδητής όσο και της υποσυνείδητης ρύθμισης. Οι συμπερφορικές μετρήσεις αναλύθηκαν μέσα από Επιβεβαιωτική Παραγοντική Ανάλυση (Confirmatory Factory Analysis), ενώ τα ηλεκτροφυσιολικά δεδομένα που λήφθηκαν από τα έργα συνειδητής και υποσυνείδητης ρύθμισης συνδυάστηκαν με τις συμπεριφορικές μετρήσεις των Επιτελεστικών Λειτουργικά και τις ψυχομετρικές μετρήσεις ψυχοπαθολογίας, προκειμένου να διερευνηθεί περαιτέρω η σχέση μεταξύ Επιτελεστικων Λειτουργικών, Ρύθμισης Συναισθημάτων και Ψυχοπαθολογίας.

Αποτελέσματα: Συμπεριφορικά Δεδομένα: Η Επιβεβαιωτική ανάλυση παραγόντων που εκτελέστηκε (Confirmatory Factor Analysis) έδειξε σημαντική συσχέτιση όλων των ψυχομετρικών μετρήσεων της ικανότητας Ρύθμισης Συναισθημάτων με τον παράγοντα της Ψυχοπαθολογίας, ενώ η επιτελεστική λειτουργία που επέδειξε τη μεγαλύτερη συσχέτιση με την ικανότητα Ρύθμισης Συναισθήματος, ήταν η Εργαζόμενη Μνήμη. Η Εκτελεστική Λειτουργία Μετατόπισης είχε σημαντική αρνητική συσχέτιση με την Υποκλίμακα Επανεκτίμησης (Reappraisal) του ERQ. Παρόλο που δεν επιβεβαιώθηκε μέσω της Επιβεβαιωτικής Παραγοντικής Ανάλυσης, η προκαταρκτική συσχετιστική ανάλυση που διενεργήθηκε αποκάλυψε σημαντική συσχέτιση μεταξύ της επιτελεστικής λειτουργίας της Συμπεριφορικής Καταστολής και των συμπεριφορικών μετρήσεων της ρύθμισης συναισθημάτων. Δεν αναφέρθηκαν σημαντικές συσχετίσεις μεταξύ της Υποσυνείδητης Ρύθμισης Συναισθημάτων και των υπόλοιπων μετρήσεων.

Ηλεκτροφυσιολογικά δεδομένα: Η ανάλυση των ηλεκτροφυσιολογικών δεδομένων, τόσο για το έργο συνειδητής ρύθμιση συναισθηματων που εφαρμόστηκαν στην τρέχουσα μελέτη (προσαρμοσμένη από Thiruchselvam et al, 2011), όσο και για το έργο υποσυνείδητης ρύθμισης ,(Egner, Aktif, Gale & Hirsch, 2008), σε συνδυασμό με τα συμπεριφορικά δεδομένα Επιτελεστικών Λειτουργιών, καθώς και τις ψυχομετρικές μετρήσεις της ψυχοπαθολογίας (SCL-90-R και PDSQ), έδειξαν ολικά μια κύρια αλληλεπίδραση των Λειτουργικών της Εργαζόμενης Μνήμης και της Συμπεριφορικής Καταστολής με ηλεκτροφυσιολογικές μετρήσεις τόσο της συνειδητής όσο και της υποσυνείδητης ικανότητας Ρύθμισης (όπως αυτές μετρήθηκαν μέσα από αλλαγές στο πλάτος του LPP). Επιπλέον, διαπιστώθηκαν δυσλειτουργίες στην τροχιά της ηλεκτροφυσιολογικής δραστηριότητας των συμμετεχόντων που παρουσιάζουν συμπτώματα συναισθηματικής διαταραχής κατά την εφαρμογή ορισμένων στρατηγικών συνειδητής ρύθμισης (Απόσπαση έναντι Επανεκτίμησης) και για ορισμένα χρονικά σημεία, καθώς και στα ηλεκτροφυσιολογικά δεδομένα της Υποσυνείδητης Ρύθμισης Συναισθημάτων, ολικά.

Συμπέρασμα: Τόσο τα συμπεριφορικά όσο και τα ηλεκτροφυσιολογικά αποτελέσματα, αποκάλυψαν το σημαντικό ρόλο της Εργαζόμενης Μνήμης και σε μικρότερο βαθμό της συμπεριφορικής καταστολής και μετατόπισης στην ικανότητα για Ρύθμιση Συναισθημάτων. Επιπλέον, τόσο οι συμπεριφορικές, όσο και ηλεκτροφυσιολογικές και ψυχομετρικές μετρήσεις της Ρύθμισης Συναισθημάτων, παρουσίασαν σημαντική συσχέτιση και αλληλεπίδραση με τα ψυχομετρικά εργαλεία Ψυχοπαθολογίας (PDSQ; SCL-90-R).που έχουν εφαρμοστεί.

Τα αποτελέσματα από την τρέχουσα μελέτη αναμένεται να συμβάλουν στον εντοπισμό των κοινών λανθανόντων μηχανισμών και ελλειμμάτων που εμπλέκονται στην ψυχοπαθολογία, τόσο σε συμπεριφορικό όσο και σε νευρωνικό επίπεδο. Η παρούσα μελέτη στοχεύει επίσης να εγκαθιδρύσει τη βάση για την εφαρμογή νευροσυμπεριφορικών παρεμβάσεων που στοχεύουν στην ενίσχυση των νευροβιολογικών κυκλωμάτων και μηχανισμών που πιστεύεται ότι βρίσκονται στης βάση της δυσλειτουργίας των Επιτελεστικών Λειτουργιών και της Ρύθμισης Συναισθημάτων και έχουν βρεθεί να εμπλέκονται σε ένα εύρος ψυχολογικών διαταραχών .

Πιο συγκεκριμένα, τα αποτελέσματα της παρούσας μελέτης αναμένεται να οδηγήσουν στη διερεύνηση της αποτελεσματικότητας καινοτόμων τεχνολογικών παρεμβάσεων που στοχεύουν να ενισχύσουν τα νευρωνικά κυκλώματα που εμπλέκονται τόσο στις επιτελεστικές λειτουργίες, όσο και στη συνειδητή και υποσυνείδητη ρύθμιση συναισθημάτων (βρίσκονται σε πιλοτική φάση, στο παρόν στάδιο)

Ο εντοπισμός των κοινών λανθανόντων μηχανισμών και ελλειμμάτων που εμπλέκονται στην ψυχοπαθολογία και η αξιοποίησή τους για την ανάπτυξη παρεμβάσεων για ένα εύρος διαταραχών με παρόμοιες δυσλειτουργίες διαδιαγνωστικά, καθώς και η μεθοδολογία της τρέχουσας μελέτης (κοινοτικό δείγμα χωρίς κριτήρια αποκλεισμού και λήψη εύρους μετρήσεων για κάθε παράγοντα), βρίσκεται σε σύγκλιση με την πρόσφατη ανάπτυξη των Ερευνητικών Κριτηρίων (RDoC) του Εθνικού Ινστιτούτου Ψυχικής Υγείας της Αμερικής, τα οποία προάγουν μια διαδιαγνωστική και νευροεπιστημονικά τεκμηριωμένη προσέγγιση στη διάγνωση και θεραπεία.

ABSTRACT [English]

Increased scientific evidence is pointing towards Emotion Regulation (ER) deficits being at the core of various forms of psychopathology. Emotion Regulation is defined by Gross (1998a), as efforts to influence which emotions one has, when he/she has them, and how he/she experiences or expresses these emotions. Emotion Regulation can be explicit (consciously activated) or implicit (initiated automatically via unconscious goals). The ability for conscious emotion regulation has been proposed to rely on the same frontoparietal and cingulo-opercular cognitive control neural circuitry as several Executive Functions (EF). However, research examining the relationship between EF and ER ability, has yielded inconsistent results. On the other hand, Implicit Emotion Regulation seems to rely on a distinct, albeit, in some aspects shared, neural network. Deficits in implicit, compared to explicit, ER seem to be most consistently implicated in several forms of psychopathology.

Given (a) the current inconsistent findings on the relationship between EF and ER ability, (b) ER's, and, especially, implicit ER's, central role in psychopathology, and (c) evidence of Executive Function Deficits in people presenting with clinical symptomatology, the aim of the current study is the investigation of the relationship between EF and ER and Affective Disorder Symptoms, via behavioural, psychometric and ERP Measures.

Sample: 120 University students (33 male, 87 female; Age, M=23,54, SD=4,98), were voluntarily recruited, from the University's of Cyprus's Department of Psychology, including students receiving services by the University's Mental Health Center. Screening tools (namely, the Psychiatric Diagnostic Screening Questionnaire, PDSQ and the Symptom Check-List-90, SCL-90) were employed as psychometric measures of affective disorders' symptomatology. Students were not excluded, on the basis of potential clinical presentation.

Measures: Standardized behavioural tasks were used for the measurement of ER and EF ability (both, explicit and implicit), while both behavioural and electrophysiological, as well as self-reported data were obtained. More specifically, EF tasks from Miyake et al., (2000), model of Executive functions (Inhibition, Shifinting, Updating) were used to measure EF ability, while a classic Emotion Regulation Task (adapted by Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011) and the Emotional Conflict Adaptation task (Egner, Etkin, Gale & Hirsch, 2008), served as measures of Explicit and Implicit Emotion Regulation, respectively. Further to psychometric measures of potential clinical symptomatology (PDSQ; SCL-90R), the Emotion Regulation Questionnaire (ERQ) and the Difficulties in Emotion Regulation Questionnaire (DERS), were administered as psychometric measures of ER ability. Changes in LPP amplitude served as a direct index of

both Explicit and Implicit Emotion Regulation. Behavioural measures were analysed via Confirmatory Factor Analysis, while ERP data taken from the Implicit and Explicit ER tasks, were combined with behavioural EF and psychometric measures of psychopathology, in order to further investigate the relationship among EF, ER and Psychopathology.

Results: Behavioural Data: A Confirmatory Factor Analysis conducted on obtained behavioural data revealed that all psychometric measures of Emotion Regulation Ability correlated significantly with the Latent Factor of Psychopathology, while the Executive Function that exhibited the greater relationship with Emotion Regulation Ability, as measured via behavioural measures, was Updating. The Executive Function of Shifting had a significant negative correlation with ERQ's Reappraisal Subscale. Even though not confirmed via Confirmatory Factor Analysis, preliminary correlational analysis revealed a significant correlation also between Inhibition and behavioural measures of Emotion Regulation. No significant relationships between Implicit ER and other constructs were reported.

Electrophysiological Data: Analysis of Electrophysiological data, both for the Explicit Emotion Regulation implemented in the current study (adapted from Thiruchselvam et al, 2011) and the Implicit Emotion Regulation Task (Egner, Etkin, Gale & Hirsch, 2008), combined with EF behavioural data, as well as psychometric measures of psychopathology (SCL-90-R and PDSQ), overall, indicated a main interaction of Updating and Inhibition with electrophysiological measures of both Explicit and Implicit ER ability (namely, changes in LPP amplitude). In addition, aberrations in the ER implementation trajectory were found for participants presenting with affective disorder symptoms for certain Explicit ER strategies (Distraction vs. Reappraisal) and certain time points, as well as for Implicit ER's overall electrophysiological data.

Conclusion: Both behavioural and electrophysiological results revealed, a greater role of Updating, and to a lesser extent, of inhibition and shifting, in ER ability. In addition, behavioural, electrophysiological and psychometric measures of ER, demonstrated a relationship and interaction with implemented psychometric measures of Psychopathology (PDSQ; SCL-90-R).

Results from the current study are expected to contribute to the identification of the common latent mechanisms and deficits involved in psychopathology, both on a behavioural and neural level. The current study also aims to establish the basis for the implementation of neurobehavioural interventions that target the neurobiological mechanisms and the specific biological and neural circuitry deficits thought to underlie aberrant EF and ER functioning, and have been found to be implicated in a range of psychological disorders. More specifically, results of the current study are expected to lead to the investigation of the effectiveness of computerized ER trainings that target both explicit and implicit ER's brain circuitry (currently, in pilot phase).

The identification of common latent mechanisms and perturbations involved in psychopathology and their utilisation for the development of interventions that cut across disorders with similar underlying deficits, as well as the current study's methodology (community sample with no exclusion criteria and obtainment of a number of measures for each investigated construct), is in line with the recent development of the National Institute of Mental Health's, Research Domain Criteria (RDoC), which proposes a transdiagnostic and neuroscientifically informed approach to diagnosis and intervention.

ACKNOWLEDGMENTS

If I were to truly express my gratitude about everyone who has contributed to the process of completing my Phd, this page would probably have a greater extent than my entire Thesis.

First of all, I would like to express my thanks to my Supervisor, Professor George Spanoudis, who has been such an awe-inspiring, compassionate and caring mentor. This process would definitely have not been completed without his always benevolent and supportive demeanour and invaluable insights. Thanks for making sure I always had someone to look up to. I cannot even put down in words all that I have gained by my interactions with you – you have constituted a human library and have caused me to develop in so many ways. I feel contentment for your recent promotion – so well deserved, and I am so pleased about its timing.

I would also like to sincerely thanks Dr. Panayiotou and Dr. Chatzittofi, members of my Scientific Committee, for reminding me of what a superb clinician and mental health practitioner is. I cannot thank Dr Schweizer enough for her support throughout, for making me think more, and for constituting such an inspiring and warm-hearting presence. It is on her ideas and insights that this thesis is mostly based. Lastly, cordial thanks to Dr. Paraskeuopoulos for all his support on taking my electrophysiological data a step further, and his always kind and supportive nature.

The list of the research's assistants both on a BA and MA Level involved in this thesis is nearly endless. This would have not been completed without you and thank so much for making me feel important by supervising and learning so much from you.

Special thanks to Savvas Antoniou for his invaluable technical assistant throughout, Myria Ioannou, Constantina Liasidou and Maria Panteli, for always being there in so many, different and meaningful ways – both technically, but mostly emotionally.

My dearest thanks also need to go to the Department's secretary, Mrs Maro Ioannou, for being more than a competent psychologist, when it was not noted in her job description. It was so soothing to reach to out to you.

I would also like to cordially thank my family and all my friends for putting up with me throughout this process. I cannot promise that the trip ends here – it probably won't. The love I have received from you from day one though, is exactly what keeps me going.

Last but not least, I would like to express my gratitude to my clients during my clinical practicum and my students, for reminding me of why what I did was important.

“ I have lived by the living people, And I have loved the living people.
But my heart was closer to the ailing with wings, the infinite insane,
and the marvellously deceased”

Miltos Sahtouris

DEDICATION

To my losses and my new gains……

and to my two beautiful Goddaughters,
who have filled my life with
Love, Joy, Pride and Gratitude.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Aim and Objectives:

The *aim* of the current study is to investigate the relationship between emotion regulation (implicit and explicit), executive functions and clinical symptomatology, as measured by standardised psychometric instruments, and both behavioural and ERP measures. For this novel aim, the current thesis entails the following three studies:

Study 1: Aims to investigate the relationship between Executive Functions (EF), Emotion Regulation (both implicit and explicit) and Psychopathology, via behavioural and psychometric measures. This study concludes with a Confirmatory Factor Analysis Model incorporating the specified constructs.

Study 2: Aims to investigate the relationship between electrophysiological measures of each Explicit Emotion Regulation Strategy studied with behavioural measures of Executive Functions, Implicit Emotion Regulation, as well as psychometric measures of psychopathology (namely, SCL-90-R and PDSQ).

Study 3: Aims to examine the relationship between electrophysiological measures of Implicit Emotion Regulation, as measured by the Emotional Conflict Adaptation Task (Egner, Etkin, Gale & Hirsch, 2008) and assess its relationship with behavioural measures of Executive Functions, as well as psychometric measures of psychopathology (namely, SCL-90-R and PDSQ).

The specific *research questions* of the current thesis are:

Research Question 1: Is there a relationship between Executive Functions, Emotion Regulation and Psychopathology, as measured by behavioural measures and psychometric measures (*Study 1*)?

Research Question 2: Which specific EF Functions, relate to each explicit Emotion Regulation Strategy? (*Study 1 and 2*)

Research Question 3: Is there a relationship between ERP measures of Explicit emotion Regulation, behavioural measures of Executive Functions and Implicit Emotion Regulation, as well as psychometric measures of Psychopathology? (Study 2)

Research Question 4: Is there a relationship between ERP measures of Implicit Emotion Regulation, behavioural measures of Executive Functions, as well as psychometric measures of Psychopathology? (*Study 3*).

Expected outcomes: Based on previous research, a relationship was expected to be found between behavioural and ERP measures of Explicit ER and EF, but not so much, on the measures of EF and Implicit ER. In addition, certain explicit ER strategies were expected to exhibit a relationship with specific EF strategies (namely, reappraisal was expected to demonstrate a stronger association with updating, while suppression was expected a greater association with inhibition). Positive correlations were expected to be found between psychometric measures of psychopathology and both measured EF and ER ability. A stronger relationship was expected to be found between Implicit ER and psychometric measures of psychopathology.

Impact/Importance:

The results of the current research are expected to contribute to the bridging of the existing bibliographic gap and inconsistent findings regarding the relationship between executive functions and emotion regulation. At the same time, the current study is expected to help identify the common latent mechanisms and deficits involved in psychopathology. This will not only serve to promote a transdiagnostic approach, in terms of assessment and diagnosis, but will also help delineate the mechanisms that will ultimately constitute future targets for treatment, for a range of disorders (both cognitive and affective).

To my knowledge this is the first study to implement a Confirmatory Factory Analysis for the investigation of the relationship between the constructs under study (EF, ER and Psychopathology).

The results of the current research are also expected to lead to the further delineation of the relationship of the measured constructs (EF, ER and psychopathology), on a neural level. Ultimately, obtained EEG data will lead to future analyses which will allow for further inferences regarding potential connections among the measured constructs, on a network and functional level.

In addition, the results of the current study are also expected to establish the basis for subsequently implementing an EF training (namely, a WM training in an affective context (Schweizer et al, 2013), and a classic WM training without emotional stimuli (Jaeggi et al., 2008), in order to target explicit ER's brain circuitry and an implicit ER training (namely, an Affect Labelling task, (Lieberman et al, 2007)), in order to target implicit ER's brain's circuitry (described in detail at the last section of the current thesis; to my knowledge also, this is the first study to propose the utilisation of an implicit emotion regulation task for the development and implementation of an implicit emotion training).

Deficits in ER's (both, explicit, bust, mostly implicit) and Executive Functions' brain circuitry, have been found to be pervasive in most forms of psychopathology (e.g. Etkin, Gyurak, & O'Hara, 2013). The possibility, therefore, of augmenting clinical symptoms, across a number of disorders, by intervening on the common neural substrates thought to underlie them, yields great prospects and is in line with the National Institute of Mental Health's vision via the development of the Research Domain Criteria (RDoC), as well as with advances in the field of cognitive training, which advocate the importance of developing novel neurobehavioural interventions that target the specific biological and neural circuitry deficits underlying psychological disorders (Keshavan, Vinogradov, Rumsey, Sherrill, & Wagner, 2014; Siegle, Ghinassi, & Thase, 2007; Vinogradov, Fisher, & de Villers-Sidani, 2012).

In the following sections, an introduction into relevant literature is provided, along with a clarification of significant theoretical concepts. For organizational purposes, further review or related research for each proposed study is provided, separately.

Theoretical Background

Research Domain Criteria (RDoC)

With the strategic purpose to advance clinical science and treatment effectiveness, and in support of a transdiagnostic and translational approach to practice, the National Institute of Mental Health, developed in 2009, the Research Domain Criteria (RDoC) Initiative. The RDoC initiative constitutes a research framework that incorporates knowledge across different dimensional constructs (genetic, neurobiological, behavioural, environmental, and experiential) of normal and abnormal functioning, in order to promote the development of an interdisciplinary science of psychopathology, that cuts across, and is agnostic to DSM diagnostic categories (Insel et al., 2010; Sanislow, et al., 2010; Morris & Cuthbert, 2012; Cuthbert & Insel, 2013a; Cuthbert & Insel, 2013b; Cuthbert & Kozak, 2013; Cuthbert, 2014; Patrick & Hajcak, 2016; Kozak & Cuthbert, 2016; Cuthbert, 2015; 2016; Sanislow, 2016a; Sanislow, 2016b; Vaidyanathan & Pacheco, 2017; Clark, Cuthbert, Lewis-Fernández, Narrow, & Reed, 2017; Sanislow, Ferrante, Pacheco, & Rudorfer, 2019; Cuthbert, 2020; Sanislow, Morris, Pacheco, & Cuthbert, 2020; Sanislow, 2020). Within the RDoC framework, mental illness is conceptualized as disorders of brain circuitries (Insel et al., 2010; Morris & Cuthbert, 2012), and genomics and clinical neuroscience are utilized, in order to identify potential perturbations in neural circuits that may span across multiple disorders and underly behavioural manifestations of clinical symptomology (e.g aberrant affect regulation and/or executive functions e.t.c.). This will allow for the identification of pathognomonic biomarkers and biosignatures of disorders and internal mechanisms that will, in turn, constitute treatment targets and guide clinical intervention (Insel et al., 2010; Morris & Cuthbert, 2012; Sanislow, 2016b; Sanislow et al, 2019).

The RDoC Framework is depicted by a dynamic, two dimensional matrix, situated within a neurodevelopment and environmental context, where the rows represent various psychophysiological constructs, regarding brain organization and functioning, and where an interaction among the specified constructs is assumed (namely, at present: negative valence systems, positive valence systems, cognitive systems, systems for social processes and arousal/modulatory systems and sensorimotor systems and their subsidiary constructs) (NIMH, 2018) .The columns of the matrix denote different units of analysis used to measure the various constructs, namely genes, molecules, cells, neural-circuit activity, physiology, behaviour, self-reports and paradigms (ibid).

The RDoC Initiative was intended to reflect NIMH's (2008) strategic plan 1.4. to "develop, for research purposes, new ways of classifying mental disorders based on dimensions of observable behaviour and neurobiological measures", and leads to the promotion of a precision medicine to clinical practice (Cuthbert & Insel, 2013b), while also consecutively, fostering a computational, data-driven approach to diagnosis, treatment and prevention (Cuthbert, 2020; Sanislow, Ferrante, Pacheco, & Rudorfer, 2019).

Note: "precision medicine" is defined by NIMH as "an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person" (NIMH, 2015).

Emotions

Emotions constitute multi-facet phenomena that involve loosely coupled changes in the domains of subjective experience, behaviour, and peripheral physiology (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Despite their putative adaptive function (Fox, Lapate, Shackman, & Davidson, 2018) (e.g. facilitation of flexible goal-directed behaviour) (Uusberg, Uusberg & Gross, 2020), emotions can become maladaptive when they unfold in the wrong intensity, duration, frequency, or type for a particular situation (Gross, 2015a), and bias cognition and behaviour (Gross & Jazaieri, 2014). Inappropriate affect is involved in most forms of psychopathology (Kring & Mote, 2016; Jazaieri, Urry, & Gross, 2013; Gross & Jazaieri, 2014; Sheppes, Suri, & Gross, 2015; Please see *Table 1* below with Emotion-Based Symptoms in DSM-5 Disorders, taken by Kring & Mote, 2016, pp.654-655). Therefore, the magnitude of our ability to successfully regulate or emotions is indispensable.

Table 1: Emotion-Based Symptoms in DSM-V Disorders

Disorders	Symptoms
Neurodevelopmental disorders	
Autism spectrum disorder	Deficits in social–emotional reciprocity; lack of facial expressions and nonverbal communication
Schizophrenia and other psychotic disorders	
Schizophrenia Schizoaffective disorder Schizophreniform disorder	Diminished emotional expression
Bipolar and related disorders	
Bipolar I disorder Bipolar II disorder Cyclothymic disorder	Elevated, expansive, or irritable mood
Depressive disorders	
Disruptive mood dysregulation disorder	Irritability
Major depressive disorder	Depressed mood, anhedonia
Persistent depressive disorder	Depressed mood
Premenstrual dysphoric disorder	Affective lability, irritability or anger, depressed mood
Anxiety disorders	
Separation anxiety disorder	Excessive fear or anxiety, persistent worry
Panic disorder	Intense fear or discomfort, persistent worry
Agoraphobia	Anxiety
Specific phobias, social anxiety disorder	Marked and persistent fear, anxious anticipation
Generalized anxiety disorder	Excessive anxiety and worry, irritability, restlessness
Obsessive–compulsive and related disorders	
Obsessive–compulsive disorder	Marked anxiety or distress
Body dysmorphic disorder	Significant distress
Hoarding disorder	Significant distress with thought of discarding objects
Trichotillomania, excoriation	Significant distress; boredom or anxiety
Trauma- and stressor-related disorders	
Reactive attachment disorder	Emotionally withdrawn behavior; limited positive affect; irritability, sadness, or fearfulness
Posttraumatic stress disorder	Distress, persistent negative emotional state, persistent inability to experience positive emotions, irritable behavior and angry outbursts
Acute stress disorder	Distress, persistent inability to experience positive emotions, irritable behavior, and angry outbursts
Somatic symptom and related disorders	
Somatic symptom disorder, and illness anxiety disorder	Persistently high level of anxiety about health or symptoms
Feeding and eating disorders	
Anorexia nervosa	Fear of gaining weight
Sleep–wake disorders	
Non-rapid-eye-movement sleep arousal disorders, sleep terror type	Intense fear and signs of autonomic arousal
Insomnia disorder, circadian rhythm sleep–wake disorders, restless legs syndrome	Clinically significant distress

(continued)

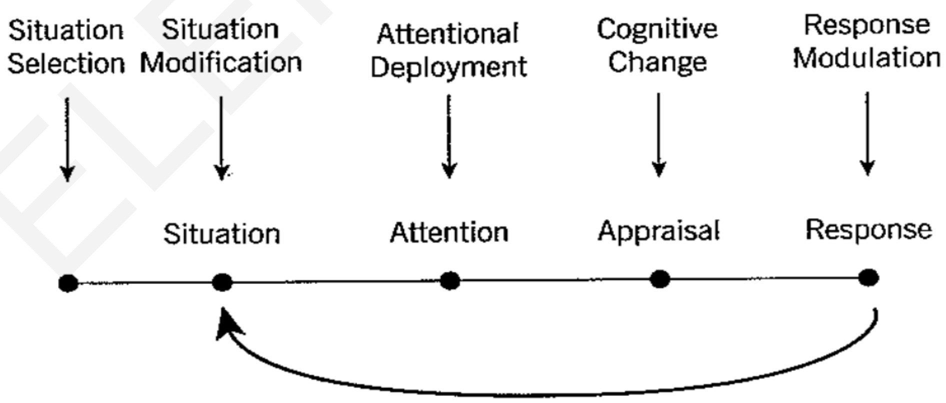
Disorders	Symptoms
Disruptive, impulse-control, and conduct disorders	
Oppositional defiant disorder	Angry/irritable mood, often loses temper, often touchy or easily annoyed
Intermittent explosive disorder	Recurrent aggressive outbursts
Pyromania	Tension or affective arousal; pleasure, gratification, or relief when setting fires
Kleptomania	Tension; pleasure, gratification, or relief at time of theft
Personality disorders	
Paranoid personality disorder	Quickness to react angrily
Schizoid personality disorder	Emotional coldness, detachment, or flattened affectivity
Schizotypal personality disorder	Inappropriate or constricted affect, excessive social anxiety
Antisocial personality disorder	Lack of remorse; irritability and aggressiveness
Borderline personality disorder	Affective instability due to marked reactivity of mood, inappropriate anger, or difficulty controlling anger
Histrionic personality disorder	Rapidly shifting and shallow expressions of emotion, exaggerated expression of emotion
Narcissistic personality disorder	Lack of empathy
Avoidant personality disorder	Fear of being shamed or ridiculed
Dependent personality disorder	Fear of loss of support or approval, being unable to care for self, being left alone
Substance-related and addictive disorders	
Alcohol withdrawal	Autonomic hyperactivity, anxiety
Caffeine intoxication	Restlessness, nervousness, excitement
Caffeine withdrawal	Dysphoric mood, depressed mood, or irritability
Cannabis intoxication	Euphoria, anxiety
Cannabis withdrawal	Irritability, anger, or aggression; nervousness or anxiety; restlessness; depressed mood
Other hallucinogen intoxication	Marked anxiety or depression
Phencyclidine intoxication	Belligerence
Inhalant intoxication	Belligerence; euphoria
Opioid intoxication	Initial euphoria followed by apathy, dysphoria
Opioid withdrawal	Dysphoric mood
Sedative, hypnotic, or anxiolytic intoxication	Mood lability
Sedative, hypnotic, or anxiolytic withdrawal	Autonomic hyperactivity; anxiety
Stimulant intoxication	Euphoria or affective blunting; anxiety, tension, or anger
Stimulant withdrawal	Dysphoric mood
Tobacco withdrawal	Irritability, frustration, or anger; anxiety; restlessness; depressed mood
Gambling disorder	Excitement; feeling restless or irritable
Amphetamine, cocaine intoxication	Euphoria or affective blunting; anxiety, tension, anger
Amphetamine, cocaine withdrawal	Dysphoric mood
Neurocognitive disorders	
Major or mild frontotemporal neurocognitive disorder	Apathy; loss of sympathy or empathy

(taken by Kring & Mote, 2016, pp.654-655)

Emotion Regulation

Emotion Regulation is defined by Gross (1998a), as efforts by "which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (p.275). Emotion Regulation can be explicit (effortful) or implicit (automatic) (Gyurak, Gross, & Etkin, 2011; Braunstein, Gross, & Ochsner, 2017; Braunstein, & Ochsner, 2018), intrinsic (initiated by self) or extrinsic (initiated by others) (Thompson,1994; Nozaki & Mikolajczak, 2020). Furthermore, according to the point in the emotion-generative process in which emotion- regulation strategies intervene, namely, before or after the full unfolding of the emotional response, they are categorized into antecedent and response-focused strategies, respectively. Within the proposed distinction, five categories of emotion regulation strategies are specified: (a) situation selection - taking actions that will make it more (or less) likely to encounter a situation that will elicit desirable (or undesirable) emotions, (b) situation modification, which involves efforts to directly alter a situation so as to modify its emotional impact, (c) attentional deployment – directing one's attention within a situation in order to influence his/her emotional response, (d) cognitive change, - changing how one appraises a situation in order to change its emotional impact (the most prominent form of cognitive change, is reappraisal, which involves changing a situation's meaning in order to modify its emotional significance) and (e) response modification, which involves efforts to influence physiological, experiential or behavioural response tendencies, after the emotion response has been unfolded (e.g. suppression, which involves efforts to inhibit one's negative or positive emotion expressive behaviour) (Gross, 1998a) (See ***Figure 1*** for Gross's, 1998, proposed Process Model for Emotion Regulation).

Figure 1: Gross's 1998, Process Model of Emotion Regulation



[taken by Gross, 2014, p.7]

Gross (2015a) further expanded his original process model, by introducing the Extended Process Model (EPM). According to the EPM (Gross, 2015a), emotions are elicited by the operation of valuation systems. Within such a valuation system, aspects of the world (internal or external), give rise to one's perception of them and, subsequently, to one's negative or positive valuations of his/her perceptions of the specific world states. This successfully activates actions (mental or physical) to alter the targeted state of the world. In our daily lives, many valuation systems – referring to different aspects of the world – are activated simultaneously and frequently interact - sometimes mutually supportive, and sometimes acting in competition. The valuation system described (world-perception-valuation-action) constitutes a first level valuation system that results in emotion generation (Gross, 2015a; Gross, 2015b; McRae & Gross, 2020; Uusberg, Uusberg & Gross, 2020; Jazaieri, Uusberg, Uusberg, & Gross, 2020)

On the other hand, and according to the same model, emotion regulation constitutes a second-level valuation system and occurs, when a first-level valuation system (generating an emotion) is taken as a target and is evaluated, either negatively or positively. This second-level valuation system, in turn, and according to the discrepancy between the current and desired state, activates action impulses that are intended to alter the first-level valuation system (namely, the emotional response).

As also proposed by Gross's (1998a) original process model, there are five ways in which the second-level valuation system can influence the first-level (emotion generative) one, by acting upon distinct positions of the initial (world, perception, valuation, action) valuation cycle. These five strategies are (1) taking steps to change the situation, and thus, state of the world one will encounter (situation selection) (2) altering one or more relevant aspects of the external world (situation modification) (3) influencing which parts of the world are attended to, and thus, affecting perception (attention deployment) (4) modifying the way the world is cognitively represented (cognitive change), and thus, affecting valuation and (5) altering emotion-related actions (response modification).

The EPM further distinguishes among three stages of the emotion regulation cycle, namely, (a) identification of the need to regulate an emotion (b) selection of the strategy to use to regulate the emotion and (c) implementation of a particular strategy that is appropriate for the situation at presence. In addition, the EPM delineates the processing dynamics (maintenance, switching and stopping) that develop as the second-level valuation system iterates over time. Emotion dysregulation might occur at any one of the abovementioned stages and processes (Gross, 2015a; Gross, 2015b; McRae & Gross, 2020; Uusberg, Uusberg & Gross, 2020; Jazaieri, Uusberg, Uusberg, & Gross, 2020). [See ***Figure 2*** for Gross's (2015a) Extended Process Model].

Figure 2: Gross's, 2015a, Extended Process Model of Emotion Regulation

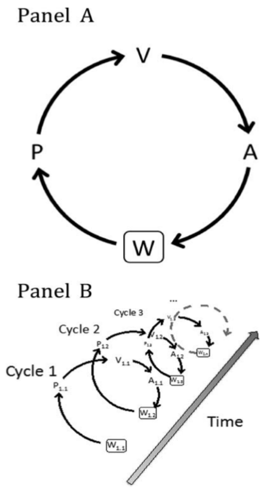


Figure 7. The valuation process. Panel A: The world ("W") gives rises to perceptions ("P"). When valued ("V") as either negative or positive, these valuations give rise to actions ("A") that can alter the state of the world. Emotion is one type of valuation, as is evident from the correspondence between Figure 7A and Figure 4B (see text for details). Panel B: Valuation takes place over time, as shown in this spiral depiction of the valuation process (adapted from Ochsner & Gross, 2014; © Guilford Press. Reprinted with permission of Guilford Press. Permission to reuse must be obtained from the rightsholder.).

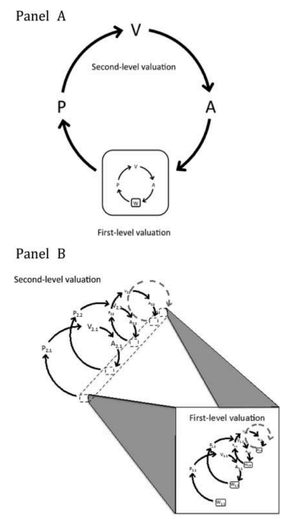


Figure 8. A valuation perspective on emotion regulation. Panel A: When the object of valuation is another valuation system—in particular, one that is instantiating emotion—emotion regulation is said to be taking place. In this case, the aspect of the world that is giving rise to the "W-PVA" cycle is itself a valuation. Panel B: These interacting first- and second-level valuation systems extend over time.

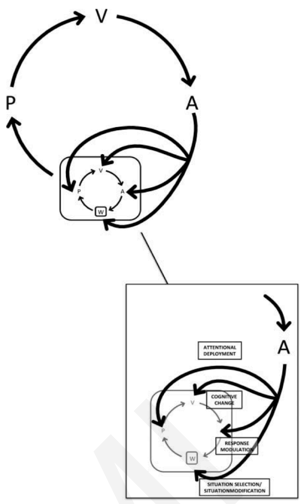


Figure 9. Emotion regulation strategies. Emotion regulation refers to actions that seek to influence emotion by changing (a) the world, (b) the perception of the world, (c) the way the world is cognitively represented, or (d) emotion-related actions. As shown in the inset, the second-level W-PVA cycle's actions represent the families of emotion regulation strategies featured by the process model of emotion regulation, namely, (a) situation selection/situation modification, (b) attentional deployment, (c) cognitive change, and (d) response modulation (note the correspondence between Figure 9 and Figure 6C).

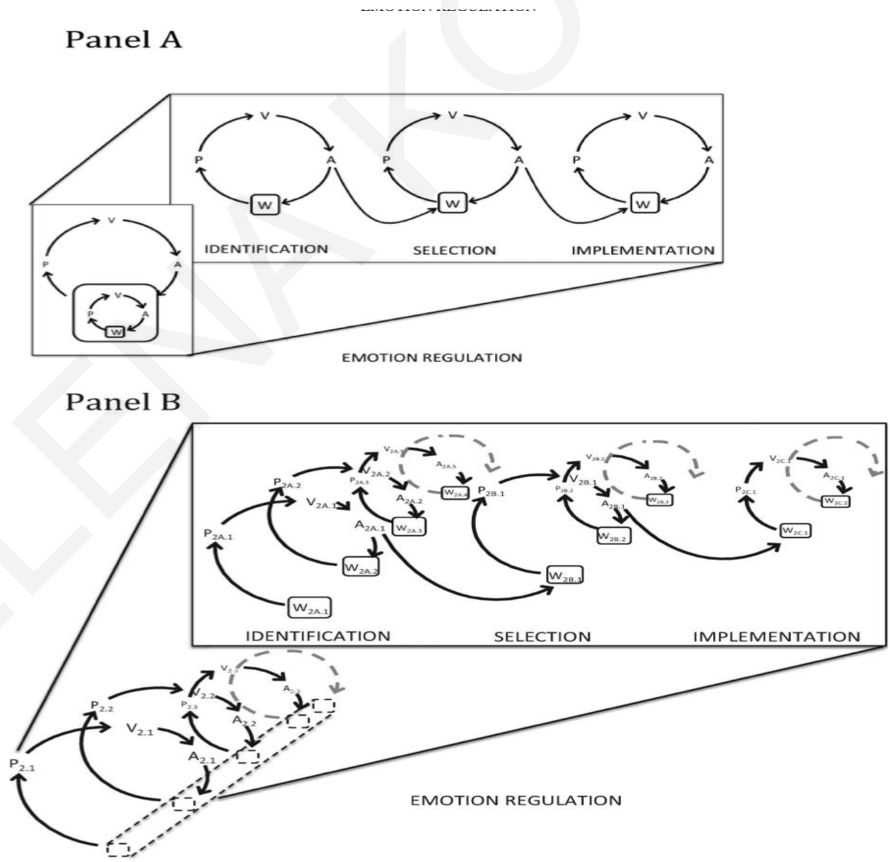


Figure 10. The extended process model of emotion regulation. Panel A: The extended process model distinguishes three stages of emotion regulation: (a) identification (which entails deciding whether to regulate), (b) selection (which entails deciding which strategy to select), and (c) implementation (which entails implementing a tactic). This may change the first-level valuation system (see text for details). Panel B: These three emotion regulation stages extend over time and are functionally linked (see text for details).

[Taken by Gross, 2015a, pp.10-13].

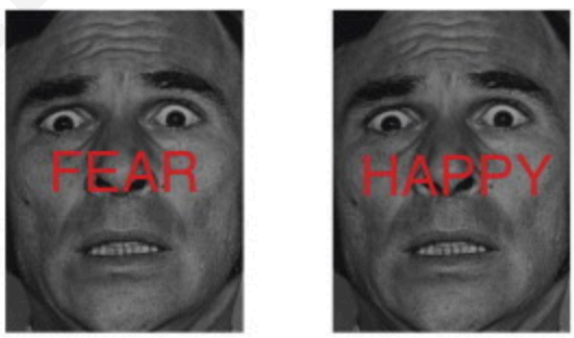
*Explicit and Implicit Emotion Regulation – A dual process framework (*Gyurak, Gross, & Etkin, 2011)

Explicit Emotion Regulation is defined as those processes which are initiated consciously, require some degree of monitoring during implementation, and entail a degree of insight and awareness. On the contrary, Implicit or Automatic/Nonconscious Emotion Regulation (IER) is defined as the regulation that occurs without an explicit instruction, is evoked automatically by the affective stimulus itself, is completed without conscious monitoring, and can take place in the absence of insight and awareness (Gyurak, Gross, & Etkin, 2011).

Gyrak, Gross & Etkin (2011) conceptualize Explicit and Implicit Emotion Regulation as two distinct, yes somewhat inter-related processes, and provide five exemplars of Implicit Emotion Regulation:

a) *Emotional Conflict Adaption* (Egner, Etkin, Gale & Hirsch, 2008). The task constitutes a variant of the classic Stroop paradigm (Stroop, 1935), where subjects are presented with photographs of emotional faces (fearful or happy) with an emotional word ("fear" or "happy") written over them. The specific word/label, either matches (no-conflict trial) or is incongruent (conflict trial) with the targeted picture. Subjects are then asked to identify whether the facial expression is happy or fearful, by pressing a button. Because reading is automatized (Stroop, 1935), during conflict trials, participants need to exhibit control over reading the word in order to successfully identify the emotional expression (Egner, Etkin, Gale & Hirsch, 2008) [See *below* for an example of stimuli from the Emotional Conflict Adaptation Task, Egner, Etkin, Gale & Hirsch, 2008]

Illustration of Emotional Conflict Adaptation Task's Stimuli



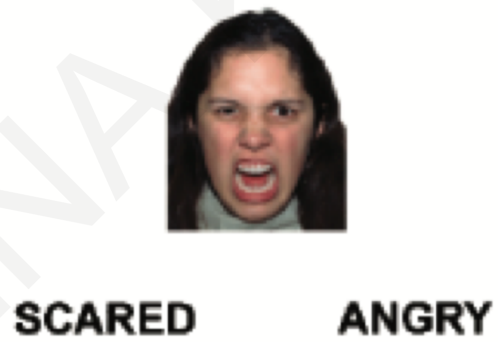
[Taken by Etkin et al, 2006, p.872]

b) *Habitual Emotion Regulation*, where the habitual/frequent pattern of engaging in an explicit emotion regulatory strategy, leads to its automatic activation, and subsequent implementation over time (Gyurak, Gross, & Etkin, 2011).

c) *Emotion Regulatory Goals and Values*, meaning the goals and beliefs one holds about emotion regulation, or even emotion themselves e.g. their malleability (e.g. Mauss & Tamir, 2014; Gutentag, Halperin, Porat, Bigman, & Tamir, 2016). Even though emotion regulatory goals are made conscious at times, e.g. when explicitly articulated (Gyurak, Gross, & Etkin, 2011), they frequently run outside of awareness and can be implicitly activated, e.g. via implementation intentions (Hallam et al., 2015), or priming (Mauss, Cook, & Gross, 2007; Hopp, Troy, & Mauss, 2011).

d) *Affect Labelling*, putting feelings into words (Lieberman et al., 2007), often implemented with no explicit regulatory intention, has been found to successfully lead to reduce negative emotional experience. In a typical affect labelling task (e.g. Lieberman et al., 2007; Hariri et al., 2000), subjects are instructed to label an emotional face, e.g. indicate whether it is angry or afraid, by matching it to its relevant affective word [see *below* for an illustration of the stimuli of the Affect Labelling Task **].** Matching emotional expressions on faces with affect label words has been, repeatedly, reported to result in diminished limbic activity and increased activity in medial and lateral cortical areas, implicated in emotion regulation (ibid).

Illustration of Affect Labelling's Task stimuli



[Taken by Lieberman et al, 2007, p.422]

e) *Error-related Regulation,* which refers to the slowing down process that occurs following the making of an error within a cognitive task (with or without emotional stimuli), in an effort to adjust cognitive control (post-error adjustment effect) (Gyurak et al., 2011).

Explicit and Implicit Emotion Regulation: A multilevel framework - Braunstein, Gross & Ochsner, (2017)

Braunstein, Gross & Ochsner, (2017), have recently proposed a multi-level framework, that organises emotion regulation strategies in a nuanced continuum (instead of a distinct explicit versus implicit emotion regulation classification), in accordance to two orthogonal dimensions (i) the nature of the emotion regulation goal (on a continuum from implicit, to explicit) and (ii) the nature of the emotion change process (on a continuum from more automatic, to more controlled). Within the specified spectrum, four classes of emotion regulation strategies emerge (see ***Figure 3***: Braunstein et al.,'s 2017, Multilevel framework of Emotion Regulation)

1. Explicit controlled, where individuals deliberately implement strategies and are conscious of their regulation process. These strategies are supported by controlled processes and exemplars include: Selective Attention, Distraction and Reappraisal.
2. Implicit automatic, which involves implicit or incidental goals that initiate regulation, which is implemented by automatic processes. Examples of such processes include instances when experiential learning mechanisms alter the contingent outcome/affective value of a stimulus, and the individual's affective response to the stimulus is updated, accordingly. Two prototypal strategies fall within this category: 1) Extinction, where a stimulus ceases to be paired with an aversive outcome and 2) reinforcer revaluation, where the positive outcome previously associated with a stimulus is either increased or diminished.
3. Implicit-controlled regulation occurs when there is an implicit goal to regulate emotion and emotion experience is changed by controlled processes. Two types of strategies fall within this type. The first one, includes instances when emotion regulation occurs as a by-product of implementing top-down control processes (e.g. response selection and/or inhibition), while performing another task. The activation of control processes has been found to exhibit a dampening effect on affective processes and hence, the goal to regulate is incidental. Examples of this strategy include tasks where individuals are asked to selectively attend to perceptual features of stimuli, such as the Emotional Stroop Task (Egner, Etkin, Gale & Hirsch, 2008) described above, or the Emotional go-no go task (e.g. Hare et al., 2005), where participants are instructed to respond to specific face targets, and inhibit their response to others. This strategy is also manifested in tasks where individuals are instructed to selectively attend/respond to semantic features of stimuli, such as the Affect Labelling task (Lieberman et al, 2007), also described above. The second type of implicit-controlled strategy refers to the use of controlled processes initiated by implicit goals that are activated either externally (e.g. via priming - automatic goal pursuit, described above), or internally (e.g. via chronic goals). An example of an internally generated implicit goal could be an organism's chronically active goal of retaining correct representations of affective value. The continuous updating of the

individual's affective response involves the activation of controlled process, and a predominant example of this strategy is reversal learning, where the organism has to change the affective value of a pair of stimuli (initially the organism is taught that the one of the two is associated with reward, and then this association changes, so that the previously nonrewarded stimulus, now becomes the one associated with reward).

4. Explicit automatic regulation entails explicit goals and more automatic change processes. Although empirical evidence for this strategy is scarce, a well-known psychological phenomenon that meets the criteria for this category are placebo effects, as they entail the expectation, or belief that a supposedly treatment will modify the emotional response to a stimulus, without the engagement of top-down control processes.

(Braunstein, Gross & Ochsner, 2017; Braunstein & Ochsner, 2018)

Figure 3: Braunstein et al.,'s 2017, Multilevel framework of Emotion Regulation

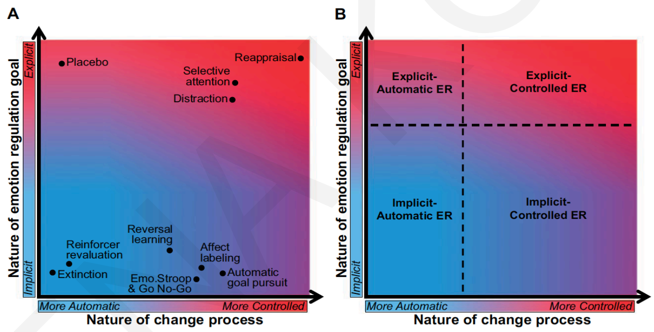


Fig. 1. Description of the psychological dimensions involved in different kinds of emotion regulation. Location on the y-axis depicts the nature of the emotion regulation goal, and location on the x-axis depicts the nature of the change process. (A) Dots represent the typically studied instantiations of emotion regulation strategies. (B) Dashed lines indicate the rough boundaries of four classes of emotion regulation.

[Taken by Braunstein, Gross & Ochsner, 2017, p.1547]

Brain Basis of ER:

Across numerous imaging studies on the neural basis of conscious emotion regulation, prefrontal, cingulate and parietal control systems, namely, the dACC, dmPFC, dlPFC, vlPFC, and vmPFC have been found to modulate activity in affective appraisal regions, such as the amygdala, the insula and ventral striatum, as well as occipito-temporal regions involved in semantic and perceptual representations (Helion, Krueger, & Ochsner, 2019; Steward et al., 2021; Berboth, & Morawetz, 2021; Doré, Zerubavel, & Ochsner, 2015; Etkin, Büchel, & Gross, 2015; Silvers, Buhle, & Ochsner, 2014; Ochsner & Gross, 2005; Kohn, Eickhoff, Scheller, Laird, Fox, & Habel, 2014; Ochsner, Bunge, Gross, & Gabrieli, 2002; Urry, et al., 2006; Ochsner, et al., 2004; Mende-SIedlecki, Kober, & Ochsner, K. N, 2011; Ochsner & Gross, 2008; Ochsner, Silvers, & Buhle, 2012; Kim &

Hamann, 2007; Schaefer, Jackson, Davidson, Aguirre, Kimberg, & Thompson-Schill, 2002; Phillips, Ladouceur, & Drevets, 2008; Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003; Beauregard, Lévesque, & Paquette, 2004; Green, & Malhi 2006). Given that most of the abovementioned areas do not share direct connections with affective areas, it has been proposed that higher order prefrontal regions might modulate subcortical limbic areas, via the mediation of intermediary areas, such as the vmPFC (Ochsner, Silvers, & Buhle, 2012; Steward et al., 2021).

With regards to Implicit Emotion Regulation, regions of the vACC- vmPFC have been mostly found to be implicated in more automatic forms of ER (Doré, Zerubavel, & Ochsner, 2015; Etkin, Büchel & Gross, 2015; Silvers, Wager, Weber, & Ochsner, 2015; Tupask, et al., 2014).

Interestingly, the ability for conscious/explicit emotion regulation seems to rely on the same frontoparietal and cingulo-opercular cognitive control neural circuitry implicated in several executive function (EF) tasks (Etkin et al., 2013), such as working memory (WM) (Doré, Zerubavel, & Ochsner, 2015; Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013).

On the other hand, areas implicated in Implicit Emotion Regulation and more specifically, the vmPFC, an area with dense reciprocal connections with the amygdala and implicated in decision making and representations of the self (Roy, Shohamy, & Wager, 2012), seem to hold a fundamental role in an array of emotion regulation related functions, such as extinction (Phelps, Delgado, Nearing, & Ledoux, 2004), reversal learning (Schiller & Delgado, 2010) and meditation (Tang, Hölzel, & Posner, 2015).

vmPFC (Myers-Schulz & Koenigs, 2014; Roy et al., 2012) and vACC (Etkin & Schatzberg, 2011) abnormalities have in particularly, been found to be implicated in psychopathology, while differential connectivity between the vmPFC and amygdala during the regulation of affective responses has been reported in a number of psychiatric populations (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007).

Emotion Regulation and Executive Functions

Cognitive control processes have been proposed to hold a central role in emotion regulation by the most prominent neural models of ER (e.g. Ochsner & Gross, 2005; Ochsner& Gross, 2008; Ochsner, Silvers, & Buhle, 2012). This is also consistent with neuroimaging data, which point towards the implication of a common cingulo-opercular cognitive control neural circuitry, in both domains (Braunstein, Gross, & Ochsner, 2017; Ochsner et al.,2012).Furthermore, previous research has indicated that the provision of

Executive Function training (namely affective working memory training) has led to transfer effects on augmented Emotion Regulation ability (e.g. Schweizer, Grahn, Hampshire, Mobbs & Dalgleish, 2013; Xiu, Zhou & Jiang, 2016), which again suggests the implication of common mechanisms among the specified constructs. Nonetheless, the two constructs are far from isomorphic and evidence on the mechanisms connecting the two, or identifying potential causal links, remains inconclusive
(Schmeichel & Tang, 2013).

Emotion Regulation seems to depend and partly be contingent on the Executive Functions. That is , ER strategies are believed to have a cognitive underpinning, with Executive Functions serving as the foundation of ER. For instance, working memory assists in the generation and manipulation of alternative scenarios in case of reappraisal, while inhibition facilitates the suppression of undesired responses (McRae et al., 2012). The application of cognitive control (i.e., inhibition, updating, shifting) in affective contexts, has been termed affective control and seems to constitute a fundamental cognitive block in the development and successful implementation of emotion regulation (for instance, see Schweizer et al, 2020).

Nevertheless, unregulated affect also seems to affect cognitive functioning (e.g. McRae, K., & Zarolia, 2020). Developmentally, emotion control processes appear earlier in development than cognitive control processes and improve throughout adolescence, which coincides with prefrontal cortex development, while early affective experiences influence theacquisition of cognitive control skills (Calkins & Marcovitch, 2010).

Zelazo and Cunningham (2007) proposed an iterative processing model to portray the convoluted interactions among emotion regulation and executive function processes. According to the specified model, emotion corresponds to the motivational aspect of cognition, within conscious, goal-directed problem-solving. Within this framework Emotion Regulation either constitutes a primary or secondary goal, but is never completely distinct/unrelated to Executive Functions. When the primary "problem" to be solved is to modulate emotion (emotion regulation), Executive Functions "just are" Emotion Regulation, with the two constructs being isomorphic. However, when modulating an emotional response is secondary to another task and occurs in the service of solving another problem, then Executive Function "involve" ER. Thus, Executive Functions and Emotion Regulation are thought to hold a reciprocal relation, the precise nature of which is dependent on the motivational significance of the problem and the involvement of "hot" (control processes centred on reward representations) or "cold" (higher-order processing of more abstract information) aspects of Executive Functions.

Nonetheless, Emotion Regulation can also occur via other routes (not necessarily through Executive Functions), and previous neuroscientific research has shown that Implicit ER seems to rely on a circuitry-specific (in relation to Executive Functions and Expicit ER) neural network (e.g. Etkin et al, 2013). Overall, Emotion Regulation's relation with Executive Functions might vary according to whether Emotion Regulation is controlled or automatic, (Zelazo and Cunningham, 2007, Pruessner et al., 2020), intrinsic or extrinsic (interpersonal), whether the goal is to down-regulate or upregulate an emotion, the type and intensity of the emotion, and the strategy employed (Zelazo and Cunningham, 2007; Ochsner, & Gross, 2008).

Indeed, current research on the relationship between specific EF measures and ER ability has yielded inconsistent results (e.g. Schmeichel & Tang, 2015; Gyurak et al, 2012; Pruessner, Barnow, Holt, Joormann, & Schulze, 2020), and as already mentioned, among the study's fundamental aims is to clarify the relationship between Executive functions and both Explicit and Implicit Emotion Regulation, separately, as well as each measured Emotion Regulation Strategy, via a variety of units of analysis (behavioural, psychometric, electrophysiological).

In the following sections, the overall Methodology of the current thesis is presented, followed by a detailed presentation of each study (relevant literature, results, discussion), separately. The present thesis concludes with implications for all three studies and provides an update of the thesis's current status (studies that are still pending/presently still under investigation). Suggestions for future research and limitations of the current thesis are also outlined.

Methodology

Sample, Experimental Procedure, Instruments and Experimental Tasks

Sample

120 University students (33 male, 87 female; Age, M=23,54, SD=4,98), were voluntarily recruited via the announcement of the purpose and procedures of the study by tutors of The Department of Psychology, and through an information leaflet that was posted on billboards at the University of Cyprus, including the University's of Cyprus's Mental Health Center. Of the initial pool of 120 participants, 3 did not complete all tasks and dropped out. All subjects were offered the amount of 20 euros, as a means of reimbursement, for their participation.

Important Note: The estimation of the current thesis's sample size was based on its ultimate aim to investigate the effectiveness of four separate interventions (more details are entailed in the final part of the thesis), upon the completion of its initial, and thus far, presented three studies. The number of imminent treatment groups which have been planned upon the completion of the currently presented studies and the proposed future statistical analysis which will be implemented to assess the effectiveness of the specified interventions (MANOVA: Repeated Measures, within – between interactions), were used for the estimation of the research's sample size – see following subsection.

Sample Size Estimation

For the purpose of estimating required sample size, a power analysis was conducted, utilizing specialized software, namely, the G*Power software (Erdfelder, Lang, & Buchner, 2007). Power was predetermined to have a value of 0.8, the effect size was estimated to have a value of Cohen's d = 0.5, while error probability was set to a = 0.05. The method of statistical analysis (MANOVA: Repeated Measures, within – between interactions), the number of groups (4), as well as the number of measurements (2), were also predetermined. According to the specified Power analysis conducted, the optimum total sample size for each group was estimated to be 28. In order to account for potential dropouts while conducting the research, the final sample size chosen for the specific study was set to 30 subjects, per group (Total n =120, for 4 groups).

Ethics Approval and Funding

The current research has gained approval by Cyprus's National Bioethics Committee (ΕΕΒΚ/ΕΠ/2020/08) and has gained funding by the "Students in Action" funding program, offered by the Youth Board of Cyprus, in cooperation with Cyprus's Ministry of Education, Culture, Athletics and Youth

Instruments

Upon obtaining informed consent, participants were sent an electronic link via email, which included all the questionnaires of the current research, and a unique subject code, which enabled their anonymized access and completion. All questionnaires were uploaded and electronically administrated, via an online survey development software, namely, Survey Monkey (SurveyMonkey Inc., San Mateo, California, USA).

The questionnaires served as a pre-test screening measure of potential clinical symptomatology, as well as a self-reported measure of Emotion Regulation (ER) difficulties and preferences in the implementation of ER strategies. Students were not excluded from the study on the basis of potential clinical symptoms.

More specifically, the following questionnaires were included in the current study:

1. Psychiatric Diagnostic Screening Questionnaire (PDSQ) (Zimmerman & Mattia, 2001)

The Psychiatric Diagnostic Screening Questionnaire (PDSQ) (Zimmerman & Mattia, 2001a) constitutes a short, psychometrically strong self-report scale, designed to examine the most common DSM-IV Axis I disorders encountered in outpatient mental health settings. It includes 126 questions assessing the symptoms of 14 disorders (across 13 clinical scales) of the DSM-IV, in 5 areas: eating disorders (eg bulimia), mood disorders (major depressive disorder [MDD], mania, hypomania, dysmorphic disorder), anxiety disorders (panic disorder, agoraphobia, PTSD, obsessive compulsive disorder, generalized anxiety disorder [GAD], post-traumatic stress disorder and social phobia / anxiety disorder / use disorders), somatic symptom disorders (somatization disorder and hypochondriasis) and psychotic disorders. These disorders were selected, due to their prevalence in epidemiological studies, in community populations, and for being the most frequently recorded, in clinical samples. PDSQ assesses both current, and recent symptomatology (ibid).

Each of the 13 scales in the English version of the questionnaire has achieved very good to excellent levels of internal validity; test-retest reliability; discriminant validity; concurrent validity and convergent validity. The internal consistency for the 13 scales of the English version of the PDSQ, ranged from a = 0.66 - 0.94 (Zimmerman & Mattia, 2001b).

The PDSQ was translated into Greek and standardized in a community population (n = 1495), by the Department of Psychology, University of Cyprus (Theodorou, Ioannou, Karekla & Panayiotou, in prep.). Overall, the Greek version of the PDSQ was found to retain high internal consistency ($\alpha = .94$), with the internal consistency of each scale also being > 7 ($\alpha = .65 - .85$) (Theodorou, Ioannou, Karekla & Panayiotou, in prep.).

PDSQ ‘s Cronbach’s Alpha for the current study was a=0.952 for the total questionnaire and ranged from a=0.699– 0.935 for all subscales, except the Psychosis Subscale, for which Cronbach’s alpha was a=0.470.

2. Symptom Checklist-90-Revised (Derogatis, 1994)

The Symptom Checklist-90-Revised (SCL-90-R; Derogatis, Lipman, & Covi 1973; Derogatis, 1994) is a brief self-report scale, consisting of 90 items, describing psychological, behavioural, and physical symptoms.

The SCL-90-R scale constitutes a widely used tool for assessing general psychopathology and symptom assessment (Derogatis, 2000), in adolescent and adult populations. It is designed for a wide range of populations, including non-clinical samples, medical samples, or samples with a psychiatric diagnosis, and has been translated, in approximately 30 languages (Derogatis & Unger, 2010). SCL-90-R can be used to evaluate the efficacy of a psychotherapeutic intervention or medication and is capable of detecting distinct clinical syndromes in epidemiological studies (Derogatis et al., 1973). A particularly important use of SCL-90-R is that of detecting mental health disorders in non-clinical populations. Nonetheless, it is utilized more as a tool for assessing general psychological distress in individuals, or populations, rather than for investigating specific psychopathology (Steer, Clark, & Ranieri, 1994).

As indicated by its name, the SCL-90-R consists of a series of 90 symptom descriptions (eg. "For the past week, how much were you bothered by: "Feeling that you are watched or talked about by others"; "Heavy feelings in your arms or legs"), rated by the subject on a 5-point Likert scale (from 0 representing Not at all, 1 A Little Bit, 2 Moderately, 3 Quit a Bit to 4 Extremely), with an average completion time of, approximately, 12 'to 15' minutes. The tool assesses the present subjective distress and symptomology of all major psychiatric disorders, with the time scope of rated symptoms and the degree of associated distress, ranging from the previous 7 days, up to the last 3 weeks. Although the SCL-90-R does not constitute a tool for assessing personality, its analysis allows for the emergence of patterns that fit into categories of personality disorders (Derogatis & Savitz, 1999).

Presented psychopathology is assessed on nine primary symptom dimensions, or subscales: (1) Somatization (12 items): complaints of physical dysfunction, (2) Obsessive-compulsive (10 items): represents the corresponding clinical disorder, (3) Interpersonal Sensitivity (9 items): symptoms of personal inadequacy, inferiority and low self-esteem, particularly in comparison to others and within interpersonal relationships, (4) Depression (13 items): refers to the corresponding clinical disorder (5) Anxiety (10 items), general symptoms and somatic manifestations of anxiety, such as nervousness, tension, trembling, apprehension, dread, terror and panic (6) Hostility (6 items): manifestations and feelings of anger and aggression (7) Phobic anxiety (7 items): mainly corresponds to agoraphobic disorder (8) Paranoid Ideation (6 items): symptoms and behaviors that represent paranoid thinking (9) Psychoticism (10 items): represents a continuum of the construct, from first-rank symptoms of psychosis, to symptoms of social alienation and isolation (Derogatis & Savitz, 1999). Seven additional items, referring to several symptoms (e.g. sleep disturbances, eating difficulties etc), are not included in the abovementioned subdivisions, but are taken into account for the extraction of the indices listed below. The scoring of each subscale results by the sum of all its individualized items (ibid).

In addition to the nine subscales, three total psychopathology indices are extracted: (a) the General Symptom Index (GDI), which provides combined information about the total number of symptoms and their associated distress (b) the Positive Symptom Total (PST), which provides information only about the number of symptoms, and (c) the Positive Symptom Distress Index (PSDI), which provides information only about the intensity of reported symptoms.

Worldwide, the SCL-90 has been standardized in many languages, with over 1000 studies documenting its psychometric properties. As far as its reliability is concerned, studies assessing its Internal Consistency, as well as Test-Retest reliability, have yielded positive outcomes (Derogatis & Savitz, 1999; Derogatis & Unger, 2010).

Derogatis et al (1976) report that the 9-dimensional Internal Consistency indices of the SCL-90-R, in a study of 209 psychiatric patients, ranged from 0.77, for the dimension VIII-paranoid ideation, to 0.90, for the dimension IV-Depression (Derogatis et al., 1976).

The Greek version of the SCL-90-R was standardized in 53 Greek-Speaking healthy subjects and 248 Greek-Speaking patients (Ντώνιας, Καραστεργίου, & Μάνος, 1991). The validity of the Greek version of the scale has been established, with its criterion validity being rated as satisfactory. Convergent validity has also been confirmed, with significant correlations reported between its subscales and relevant MMPI subscales (Σταλίκας, Τριλίβα, & Ρούσση, 2012).

SCL-90-R's Cronbach's Alpha for the current study was significantly high for the toal questionnaire (a = 0.97) and ranged between a=0.634 -0.81, for each of its subscales.

3. Difficulties in Emotion Regulation Questionnaire (Gratz & Roemer, 2004)

The Difficulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) constitutes a self-report questionnaire, that was developed for providing a comprehensive and multidimensional assessment of emotion regulation dysfunction.

The theoretical model underlying DERS (Gratz & Roemer, 2004), derives from third-wave Cognitive-Behavioural Therapy models, which point to experiential avoidance's focal role in the onset and perpetuation of emotional disturbances, and proposes four broad aspects of emotion regulation:(a) awareness and understanding of emotions; (b) acceptance of emotions; (c) the ability to control impulses and behave in accordance with goals, in the presence of negative affect; and (d) access to effective emotion regulation strategies , and display of flexibility in their implementation, in order to attain individual goals and meet situational demands.

According to the proposed model, DERS assesses Emotion Regulation difficulties in the following six dimensions:(a) lack of emotional awareness (*Awareness*), (b) difficulty in accepting emotional responses (Acceptance), (c) lack of emotional clarity (*Clarity),* (d) difficulty in controlling behavioural impulses, when distressed (*Impulse),* (e) difficulty in engaging in goal-directed behaviour, when distressed (*Goals*), (f) limited access to effective emotion regulation strategies, when distressed (*Strategies*) (Gratz & Roemer, 2004).

The English version of the Difficulties in Emotion Regulation Scale (DERS) includes 36 questions, covering the above six dimensions: Awareness (e.g. "I Pay attention to how I feel", 6 items), Clarity (e.g. "I have difficulty making sense out of my feelings ", 5 items), Impulse (e.g.," When I'm upset, I become out of control "; 6 items), Goals (e.g. "When I'm upset, I have difficulties focusing on other things", 5 items), Acceptance (e.g. "When I'm upset, I start to feel very bad about myself" (6 items) and Strategies (e.g. "When I'm upset, i know i can find a way to eventually feel better "8 items). Participants indicate how often each statement applies to themselves, on a scale from 1-5 (1: almost never, to 5: almost always).

The DERS has been widely established, as a reliable and valid instrument for measuring emotion regulation difficulties, in several English-speaking, and, mostly, clinical populations (Hallion et al, 2018; Mitsopoulou, Karademas, Kafetsios, & Papastefanakis, 2013), including emotional disorders (Hallion et al, 2018)

The English version of the DERS has been found to have high internal consistency (a = .93), good test-retest reliability, adequate construct validity, and preventive validity. (Gratz & Roemer, 2004). The internal validity of each subscale of the English questionnaire was found to be> 80 (a = .80 - .89) (ibid).

The DERS has been translated (forward-backward translation) and standardized in Greek, in a community population of 708 adults, from 13 major regions of Greece, by Mitsopoulou, Karademas, Kafetsios and Papastefanakis (2013).

Overall, the Greek version of the DERS has proved to retain high internal consistency, while the internal consistency of each scale was also> 7 (α = .73 - .87) (Mitsopoulou, Karademas, Kafetsios, & Papastefanakis, 2013).

DERS's Cronbach's Alpha for the current study was a = 0.937 for the total questionnaire, and ranged between a=0.771- 0.891, for each of its subscales.

5. *The Emotion Regulation Questionnaire, (Gross & John, 2003)*

The Emotion Regulation Questionnaire (Gross & John, 2003) is a 10-item self-report scale, designed to assess individual differences in the systematic use of two Emotion

Regulation strategies: Reappraisal and Suppression (Gross & John, 2003). Participants respond to each item, using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree).

The Reappraisal subscale consists of 6 items (1,3,5,7,8,10; e.g. " When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm"), while the Suppression subscale, consists of 4 items (2,4,6,9; e.g. When I am feeling *negative* emotions, I make sure not to express them ").

The ERQ has demonstrated sufficient internal consistency reliability and concurrent/criterion validity (Preece et al, 2019), with the mean Cronbach's alpha ranging from .79 for the Reappraisal scale, and .73 for the Suppression scale, in the English-speaking sample of undergraduate students it was initially administrated in (Gross & John, 2003).

The questionnaire has been translated in Greek by Dr. Kafetsios (Department of Psychology, University of Crete), via forward-backward translation, and has, since, been implemented in greek-speeking populations in several educational, occupational and general contexts (Σταλίκας, Τριλίβα, & Ρούσση, 2012).

Regarding the reliability of the Greek version of the ERQ, the translated instrument has provided satisfactory ratings of internal reliability, in a standardisation sample of 485 educators. Cronbach's alpha was 0.84 for the reappraisal subscale and 0.72 for the Suppression Subscale (Kafetsios & Loumakou, 2007).

ERQ's reliability for the current study was a= 0.90 for the reappraisal subscale, and a=0.75, for the Suppression subscale.

Experimental Procedure – Experimental Tasks and Measures

Upon completion of the research's questionnaires, participants were invited to the Centre of Applied Neuroscience, at the University of Cyprus, for the administration of the experimental tasks of the study, and the collection of behavioural and electrophysiological measures.

The administration of all experimental tasks was divided in two parts. Hence, participants were asked to present themselves at the Experimental Lab, for a total of two visits. The first visit entailed the obtainment of electrophysiological and behavioural measures, while the second visit involved the obtainment of behavioural measures, only.

Experimental Tasks

E-prime 3.0 (Psychology Software Tools, Pittsburgh, PA) and OpenSesame (Mathôt, S., Schreij, D., & Theeuwes, J., 2012), were utilized for the design and administration of all experimental tasks included in the current study. For all copy righted materials, relevant permissions of use were obtained.

All instructions and stimuli were translated and adapted to Greek, upon gaining relevant permission of use, and all stimuli and tasks were administrated in advance for piloting purposes, to an independent pool of students, which was not included in the research's final sample.

A complete description of all experimental tasks follows.

Executive Function Tasks

For the purposes of the current project, the seminal work of Miyake et al., (2000), on the underlying factor structure of executive functioning, that delineates *Inhibition*, *Shifting* and *Updating* as three interrelated, but empirically distinct components of executive functioning, was applied.

Within this framework, two of the three behavioural tasks implemented by Miyake et al., (2000) and Friedman et al, (2016) [more specifically, the ones presenting greater latent loadings on each executive function, according to the Confirmatory Factor Analysis conducted by Miyake et al., (2000)], where utilized for measurement purposes.

Namely:

- (1) the Antisaccade task (Hallett, 1978) and the Stroop task (Stroop, 1935), were used to measure inhibition.
- (1) The Number–Letter task (Rogers & Monsell, 1995), and the Category Switch task (Mayr & Kliegl, 2000) were used to measure shifting.
- (1) the Letter Memory task (Morris & Jones, 1990) and the Keep Track task (Yntema, 1963), were used to measure updating/ working memory.

Out of the two, the one with the highest latent variable loadings (Miyake et al., 2000) was chosen for obtaining the ERP data, and, thus, were implemented during the participants' first visit.

Inhibition

1. Antisaccade (Hallett, 1978)

This response inhibition task asked subjects to avoid the automatic tendency to look at a cue, and, instead, turn their gaze to the opposite direction, to see a rapidly presently visual stimulus. The time frame between cue and stimulus was predetermined in such a way, that it was impossible for the participants to view the stimulus, if they first performed a saccadic movement towards the direction of the cue.

The task started with a prosaccadic block (20 trials), to familiarize participants with the procedure, and intensify the prepotency of the prosaccadic reaction, followed by three antisaccatic blocks (38 trials each – each one, more demanding than the preceding one).

Each trial began with a fixation cross, projected in the center of the screen. After a variable time-interval (one of nine time-intervals, varying from 1,500 - 3,500 ms), the fixation crossed disappeared, and the cue (a black square 3,175 mm, inner edge 8.5725 cm from the center of the monitor), appeared, either, on the left, or right side, of the screen (with equivalent probability rate). The cue’s presentation duration was 233 ms for the first antisaccade block, 200 ms for the second, and 183 ms for the third, and initial prosaccade block. As soon as it disappeared, a numerical stimulus (a digit 1-9, in Helvetica font, projected on a square 1.11125 cm, with its inner edge set to 8.255 cm from the fixation point), was displayed for 150 ms, before being masked by a grey cross-hatching, on the same side as the cue, for the prosaccade block, and on the opposite side, for the antisaccade ones.

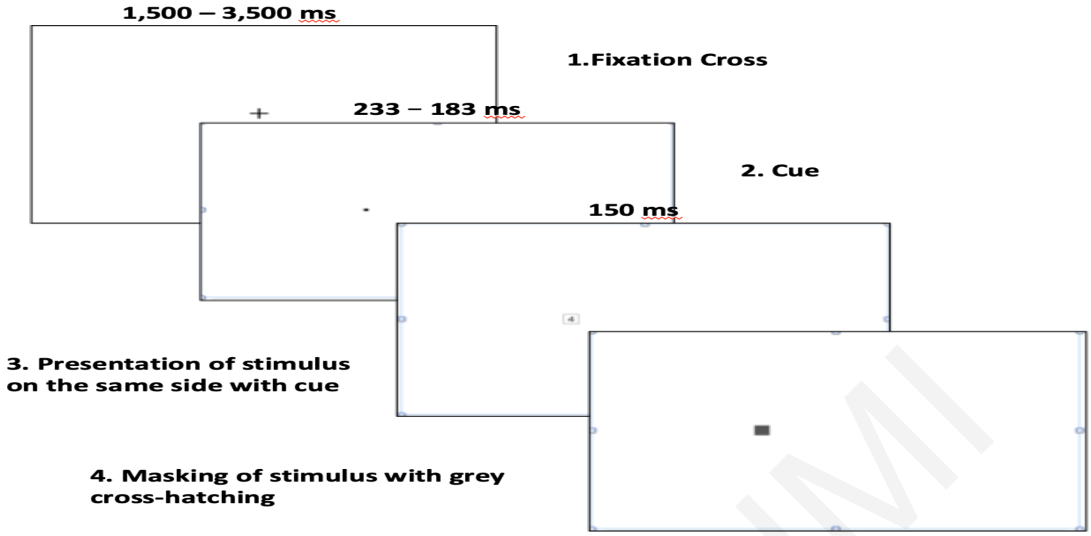
Participants were required to indicate the target number (or the one they assumed that they had seen) by pressing the corresponding number, on the keyboard. Stimuli were presented in pseudorandom order, so that each number was represented for an equal number of times, in each block. Within each antisaccade block, certain numbers were repeated in successive trials (twice, in each block). However, the repeated number, always appeared on the opposite side of the previous trial.

12 practice trials preceded the prosaccade and first antisaccade block, while two "warm-up" trials were included in all antisaccade blocks and were eliminated from the analysis.

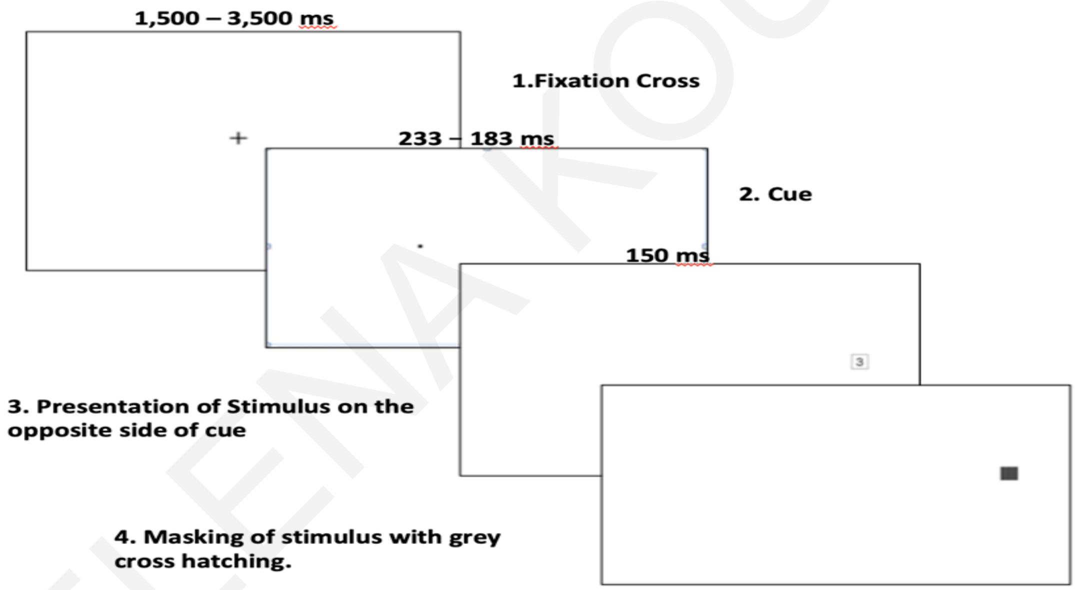
The dependent variable constituted the proportion of correct responses (average accuracy), across all three antisaccade blocks.

Illustration of task:

Example of prosaccade trial



Example of antisaccade trial



2. Stroop (Stroop, 1935)

In this response inhibition task, participants were required to avoid the prepotent inclination to read words that describe colours, and instead name aloud (via a microphone), the colour (red, blue or green), in which the word was printed in. Stimuli were presented on a black background, and each trial began with a 750 ms blank period, followed by a white fixation cross, and then by the coloured stimulus, which was left on the screen, until the participants produced a response.

Three types of experimental trials were included in the task: 1) the first block entailed 42 neutral trials (no response conflict), where participants were presented with coloured strings of asterisks, of varying length (3-5), printed in red, blue, or green; 2) the second block consisted of 42 trials words describing colour (RED, BLUE, and GREEN), printed in the matching colour e.g. “BLUE” printed in blue (congruent block), and 3) the final two blocks contained 42 trials of words describing colour, printed in colours different to the one they described e.g. “BLUE” printed in green (incongruent trials – response conflict).

Participants were asked to name out load the colour in which the stimuli were displayed in, as quickly and accurately, as possible. A microphone was connected to the computer, which allowed for the recording of the content of subjects’ responses, as well as their response latency. Voice recordings for each subject were then individually listened to and scored.

Stimuli were presented in pseudorandom order, so that the three words that describe colour (or strings of asterisks) and the three colours in which the stimuli were printed in, (1) appeared with equal probability in each block, and (2) no more than three consecutive trials, included the same word, string of asterisks, or colour of stimuli.

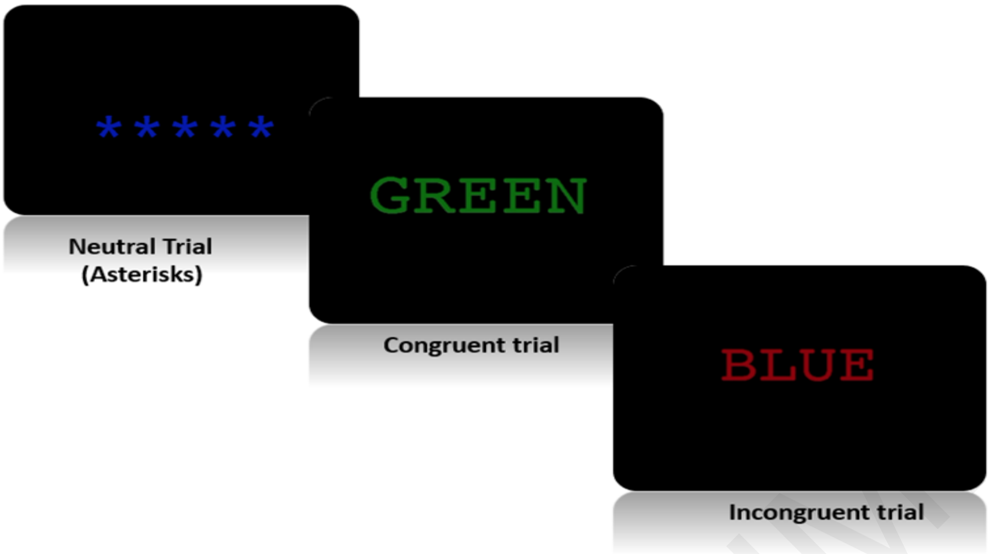
10 practice trials preceded the first two blocks and every block entailed two “warm-up” trials, that were eliminated from the analyses.

In general, there is a tendency in subjects’ responses in this task to present a pattern of facilitation, in trials in which there is a congruency between the colour that the word is referring to, and the one in which it is printed, compared to neutral trials. On the contrary, incongruent trials demonstrate a pattern of response interference.

In congruent trials, correct answers might occur in both, a task-appropriate (response based on the stimulus font), and a task-inappropriate manner (subject produced the response by reading the word e.g. read “BLUE” and said blue). For this reason, neutral trials ("***" in blue), serve as a more suitable baseline measure of the time required for a reaction, on the sole basis of colour font.

Hence, the dependent variable was computed as the difference between the average reaction time of the correct responses in the incongruent trials (response conflict), versus the asterisks block (neutral trials). Errors, hybrid (e.g. greblue) and stutter responses, or trials relating to recording malfunction, were not included in the analysis.

Illustration of Task:



Shifting

1. Number–letter task (Rogers & Monsell, 1995)

In each trial of this shifting task, a number–letter or letter–number pair, was presented in one quadrant of a square (numbers varied from 2-9 and letters included the Greek characters A, E, I, Y, Γ, K, M, and P).

When the pair of stimuli appeared in one of the two top quadrants, subjects were instructed to categorize the number as odd, or even. When the pair appeared in one of the two bottom quadrants, subjects were instructed to categorize the letter as a consonant, or a vowel.

Participants were instructed to press a key on the keyboard to categorize the, differing each time, target stimulus (the left arrow key classified the stimulus as an even number /consonant, while the right arrow key, classified the stimulus, as an even number / vowel).

Participants were initially required to complete two blocks, of 32 trials each, where the number-letter/letter-number pair was presented only in the top two quadrants of the square, and then only in the lower two quadrants (single task blocks).

12 practice trials preceded each one of these blocks, while each block entailed two additional "warm-up" trials.

Upon completion of the single-task blocks, participants were presented with 2 blocks (64 trials each) of predictable switches, where stimuli appeared in a clockwise pattern, enabling subjects to anticipate which kind of categorization they were asked to perform next. Both blocks included 4 "warm-up" trials and occurred after the completion of 12 relevant practice trials.

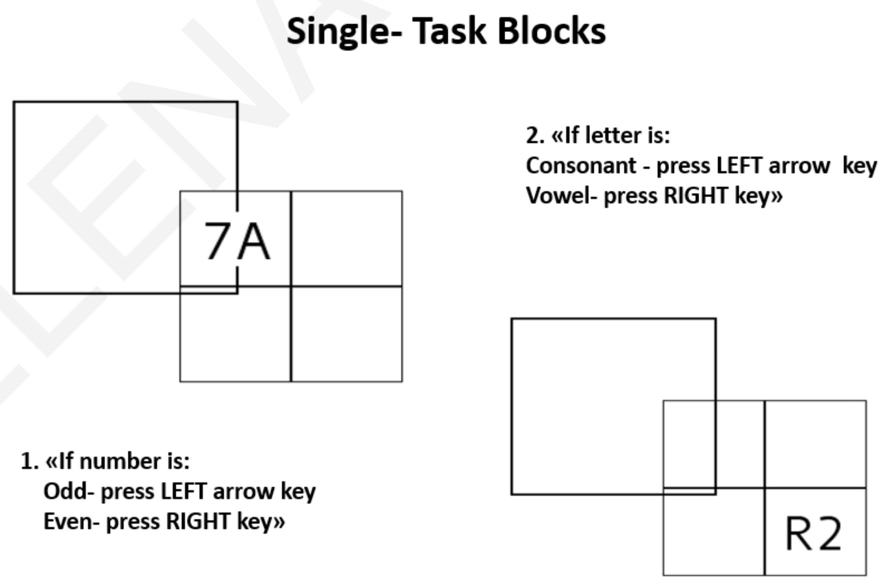
Finally, subjects were presented with 2 random switch blocks, in which the stimulus's location of each trial was randomly and, thus, unpredictably, assigned, but for which they received a 350 ms cue, prior trial onset. The cue constituted a thick black square that overlaid the quadrant in which the target stimulus-pair would appear. The completion of the random-switch blocks occurred after the completion of 24 relevant practice trials, while each block included 4 additional "warm up" trials, that were eliminated from the analysis.

Both the cue and the stimulus (letter / number pair) remained on the screen, until the participant produced a response, by pressing the analogous key (left arrow for odd number or consonant, right for even number or vowel). This, subsequently, triggered the next trial, which appeared 350ms later (350ms response-to-cue interval).

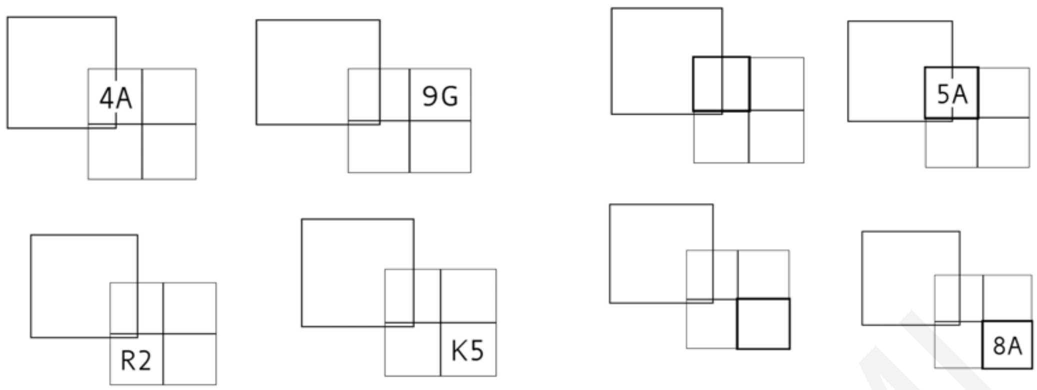
Throughout the task, participants were instructed to respond as accurately and quickly as possible, and a 200-ms tone sound buzzed after each erroneous response.

The dependent measure constituted the switch cost in the random switch blocks, which was calculated as the difference in average reaction times between correct switch trials and correct repeat trials. Trials that followed errors, were not included in the analysis.

Illustration of Task:



Mixed Blocks



3. Predictable Switches (Clock-wise Rotation of target stimulus-pair).

4. Random-Switch Blocks, (Cued 350ms, prior to target-stimulus Presentation).

2.Category Switch (Mayr & Kliegl, 2000)

In this shifting task, participants were presented with words (one at a time), that could be categorized, both as describing living organisms or non-living objects, as well as things smaller or bigger than a football (e.g. mushroom, oak, marble, cloud). A certain symbol, either a heart or crossed arrows, appeared for 350 ms prior to the target word, and remained above the word for the entire trial, in order to indicate the type of categorization participants were asked, each time, to perform (living/non-living or small/big).

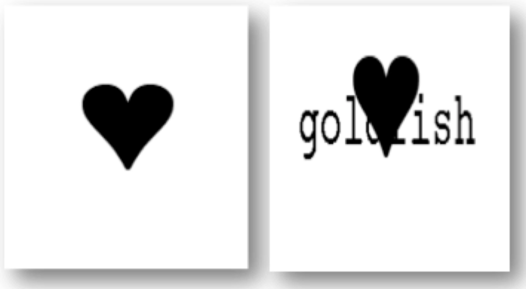
Participants were instructed to press specific buttons to categorize the word (left arrow key for non-living or small objects, right for living organisms and big objects), while a sound, with a duration of 200ms, signalled an incorrect answer. Each word remained on the screen until an answer was provided, and the next trial began 350 ms post-response.

The task began with two single-task blocks (32 trials each), where participants were required to categorize the words, based on a single dimension (living/nonliving and then, small /big). Both blocks were preceded by 12 practice trials, and included two "warm-up" trials, which were eliminated from the analysis.

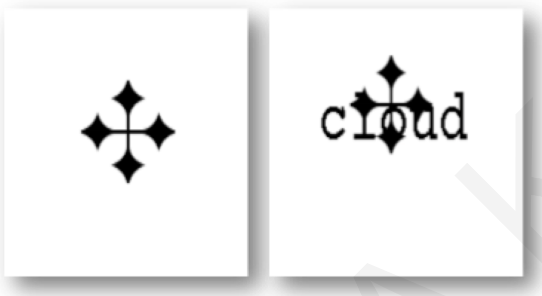
Participants subsequently, completed two mix blocks (64 trials), in which the two subtasks [classifying words according to (1) living status (2) size] were pseudorandomly ordered, such that half the trials required switching from one subtask to the other. Each mix block was preceded by 24 practice trials, and included 4 additional “warm up” trials, which were not included in the analysis.

The dependent measure, was again, the local switch cost, which was computed as the difference in average reaction times between correct switch trials and correct repeat trials, for the mixed blocks. Trials that followed errors, were also eliminated from the analyses.

Illustration of Task:



«When the word appears with the heart symbol:
If the word describes something that is:
NONLIVING- press the LEFT key button
LIVING- press the RIGHT button».



«When the word appears with the crossed arrows:
If the word describes something that is-
SMALL- press the LEFT button
BIG- press the RIGHT button».

Note:
All stimuli were used with permission (Miyake et al., 2000 and Friedman et al, 2016), and translated and adjusted to Greek, accordingly.

The words that described non-living things were:
νιφάδα χιονιού, βότσαλο, βόλος, πόμολο, ποδήλατο, παλτό, τραπέζι, σύννεφο
(initial pool of words: snowflake, pebble, marble, knob, bicycle, coat, table, and cloud).

The words that described living things were:
σπουργίτι, μανιτάρι, σαύρα, χρυσόψαρο, λιοντάρι, καρχαρίας, αλιγάτορας και δρυς
(initial pool of words: sparrow, mushroom, lizard, goldfish, lion, shark, alligator, and oak).

The words that described small things were:
νιφάδα χιονιού, βότσαλο, βόλος, πόμολο, σπουργίτι, μανιτάρι, σαύρα, χρυσόψαρο
(initial pool of words: snowflake, pebble, marble, knob, sparrow, mushroom, lizard, and goldfish).

The words that described big things were:
ποδήλατο, παλτό, τραπέζι, σύννεφο, λιοντάρι, καρχαρίας, αλιγάτορας και δρυς
(initial pool of words: bicycle, coat, table, could, lion, shark, alligator, and oak).

Participants were offered adequate time to familiarise themselves with the words, and any queries regarding the meaning of words, or their categorization, were clarified, prior to task onset.

Updating

1.Keep track task (Yntema, 1963)

This updating task required participants to keep track of the last items of two to five categories (animals, colours, countries, distances, metals, and relatives), in a series of words presented to them, from a total of six categories.

Each trial began with the names of the categories from which participants were asked to recall the last item, which remained on the bottom of the screen throughout stimuli presentation. Subsequently, 15-25 words from all categories appeared on the screen, one by one, for a duration of 2scs each. At the end of each trial, the names of the categories disappeared, and three question marks (???) appeared on the screen, notifying subjects to name out loud the last word they could recall seeing, from each target category.

The phrase GET READY was presented on the screen for 2secs before each trial, and the actual trial started after 1 sec.

The task consisted of 4 blocks, with each block containing one trial of two, three, four and five categories, in randomized order for each block (task's total number of trials: 16, with 4 trials for each level of difficulty).

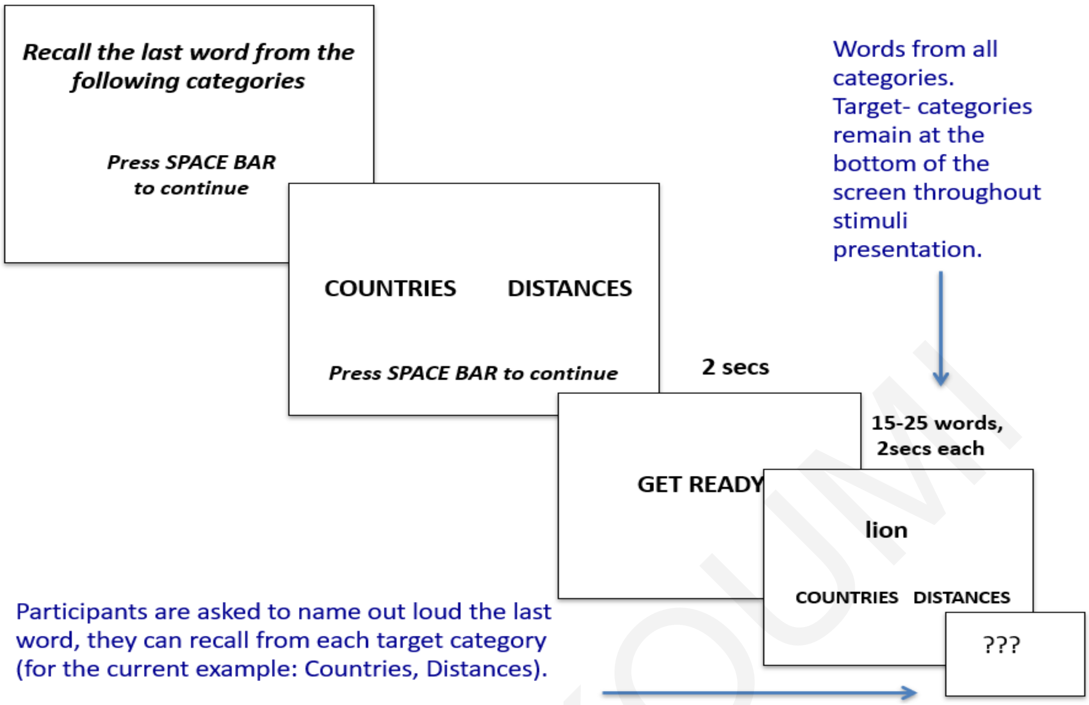
Actual trials were preceded by 2 practice trials, where participants were asked to recall the last word of two categories only.

Subjects were prohibited from repeating the words or categories out loud, during stimulus presentation, and prior to the designated time of producing their final recall.

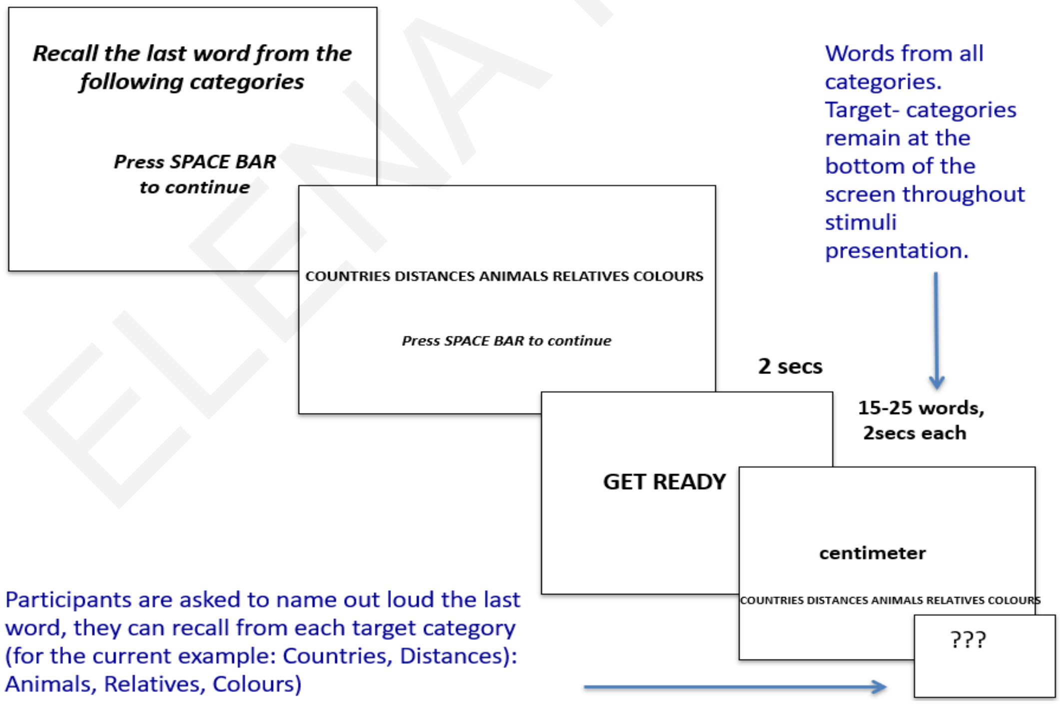
The dependent variable was estimated as the proportion of correct words recalled, across all 16 trials.

Illustration of Task:

Example of Trial with 2 categories to keep track of:



Example of Trial with 5 categories to keep track of:



Note:

All stimuli were used with permission (Miyake et al., 2000 and Friedman et al, 2016), translated and adjusted to Greek, accordingly.

Categories and letters included in the task were as follows:

ΣΥΓΓΕΝΕΙΣ : Θεία, Θείος, Πατέρας, Μητέρα, Αδερφός, Αδερφή
(Initial Pool: RELATIVES: Aunt, Uncle, Father, Mother, Brother, Sister)

ΑΠΟΣΤΑΣΕΙΣ: Μίλι, Πόδι, Ίντσα, Γιάρδα, Μέτρο, Εκατοστόμετρο
(Initial Pool: DISTANCES: Mile, Foot, Inch, Yard, Meter, Centimetre)

ΜΕΤΑΛΛΑ: Σίδηρος, Χαλκός, Ατσάλι (Χάλυβας), Τενεκές (Λευκοσίδηρος), Ψευδάργυρος, Πλατίνα
(Initial Pool: METALS: Iron, Copper, Steel, Tin, Zinc, Platinum)

ΖΩΑ – Σκύλος, Γάτα, Άλογο, Αγελάδα, Λιοντάρι, Τίγρης
(Initial Pool: ANIMALS: Dog, Cat, Horse, Cow, Lion, Tiger)

ΧΡΩΜΑΤΑ – Μπλε, Κόκκινο, Πράσινο, Κίτρινο, Πορτοκαλί, Μαύρο
(Initial Pool: COLOURS: Blue, Red, Green, Yellow, Orange, Black)

ΧΩΡΕΣ- Μεξικό, Γαλλία, Αγγλία, Ρωσία, Γερμανία, Καναδάς
(Initial Pool: COUNTRIES: Mexico, France, England, Russia, Germany, Canada)

Participants were offered adequate time to familiarise themselves with the words, and any queries regarding the meaning of words or their categorization were clarified, prior to task onset.

2.Letter memory task (Morris & Jones, 1990)

In this updating task, participants were asked to continuously repeat the last four letters of a series of letters (consonants only), the length of which was not predictable (9, 11, or 13 letters).

As a sequence of letters appeared on the screen, participants were instructed to rehearse aloud the last four letters presented to them (including the current one) in order of presentation, accumulating the most recent one and dropping the fifth one from the end, when a total of 4 letters was reached, in order to ensure that only 4 letters, each time, were retained and repeated (e.g. if the sequence of letters were K-S-T-M-Z-P-D – presented one by one – they had to repeat out loud K, K-S, K-S-T, K-S-T-M, S-T-M-Z, T-M-Z-P. M-Z-P-D).

Each letter was displayed for 3s. After displaying 9, 11 or 13 letters, three question marks appeared on the screen, prompting subjects to name the last four letters they had seen, in order of presentation.

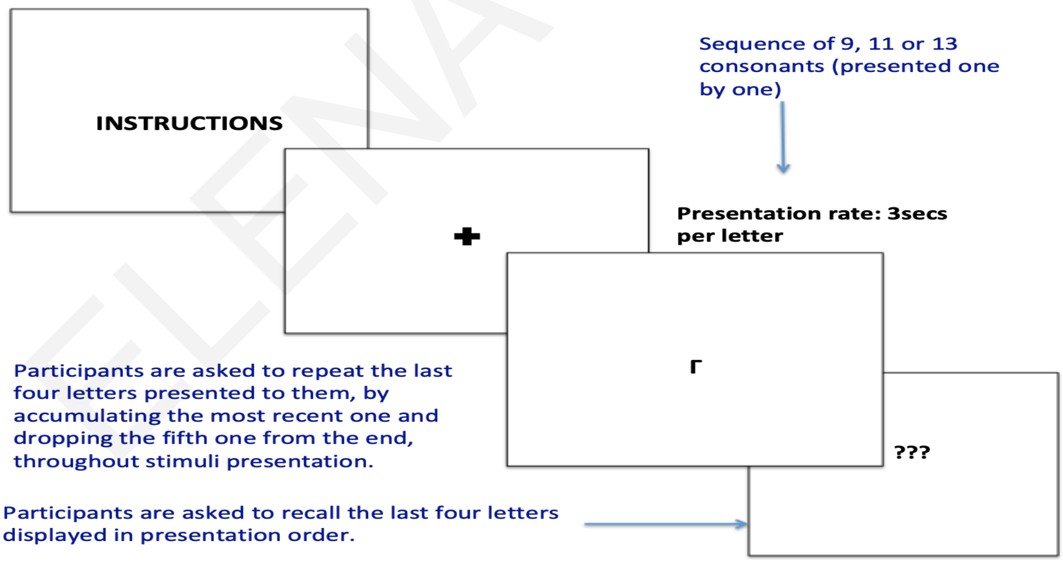
In case subjects were unable to recall a letter, either during practice, or actual trials, they were instructed to say the word «blank», instead.

One point was given for each set of 4 letter recalled accurately and in the correct order, during rehearsal. At the end of each sequence of letters, participants were asked again to recall aloud the last four letters of the sequence, even though their final recall was not scored, as it was already entailed in the set score for the last letter.

The task included a total of 12 actual trials, where there were 4 trials of each varying letter-sequence length (9, 11 or 13) and 3 practice trials (two 7-letter and one 9-letter trial).

The dependent measure constituted the proportion of sets that were accurately recalled and repeated.

Illustration of task:



Note:

Greek consonants were used for this task. Letters for each sequence and trial were carefully selected, to establish as much homogeneity as possible, in terms of level of difficulty in letter pronunciation (e.g. number of syllabuses, potential phonological rhyming with previous and subsequent letter, articulation - body part used for producing sound i.e. lateral, nasal, fricative, voiceless, voiced e.t.c), and therefore, control for considerable strain in recalling, and ensure rather comparable Working Memory load.

Emotion Regulation Tasks

Explicit Emotion Regulation Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)

A classic Explicit ER paradigm (e.g. Fernandez, Jazaieri, & Gross, 2016) was employed, where participants were presented with a series of pictures from the International Affective Picture System (IAPS; Lang et al. 2008), and were instructed to watch passively on half of the trials, and instructed to implement an explicit ER strategy, namely, reappraisal, distraction or suppression, on the other half. Strategies were segmented in different blocks, in order to explore the, potentially, diverse relation of each strategy to each separate cluster of executive functions.

More specifically, for the purposes of the current thesis, an Emotion Regulation Task taken and adapted by Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, (2011), was implemented. The task consisted of 168 trials, divided into 6 blocks of 28 trials, each. The task included five conditions: VIEW (neutral images), WATCH (negative images), DISTRACT (negative images), REAPPRAISE (negative images) and SUPPRESS (negative images). For the 168 trials, 5 different blocks of images, taken by the International Affective Picture System (IAPS; Lang et al. 2008) (4 negative and 1 neutral), were used.

For the VIEW (ΘΕΑΣΗ) and WATCH (ΠΑΡΑΚΟΛΟΥΘΗΣΗ) trials, subjects were instructed to simply attend to the image presented, allowing themselves to experience any thoughts or feelings that emerged.

The VIEW and WATCH conditions were functionally identical, as in both, subjects were asked, merely, to passively attend to the presented stimuli. Nonetheless, as implicated by Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, (2011), two different cues were chosen, in order to ensure equivalent anticipatory knowledge level of subsequent image, for all conditions. These trials served as an index of unregulated responding to emotional stimuli.

For the REAPPRAISE trials, subjects were asked to try and produce a neutral emotional response to the presented images, by modifying their construal of their negative content, either by: (a) imagining a positive outcome for the displayed scenario (e.g. that it will improve over time), or (b) by retaining the perspective of a remote/ detached observer (e.g. imaging that the image is taken from a film, and, thus, is not real).

For DISTRACT trials, subjects were asked to try and produce a neutral emotional response to negative images, by producing thoughts that were irrelevant to the depicted stimuli, such as by eliciting mental imageries of complex geometrical shapes, or by visualizing common scenes and routes/roads around their hometown.

For SUPPRESS trials, subjects were asked to voluntarily suppress their emotion-expressive behaviour. More specifically, they were explicitly asked not to let their emotions become apparent, so that, in the event that another person was watching them, he/she would not be able to distinguish that they were feeling anything (This condition was not included in the original task by Truchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011 and it was taken and adapted by: Gross, 1998b; Goldin, McRae, Ramel, & Gross, 2008].

When translating instructions from English to Greek, for the purposes of the current research, and in line with the original authors' guidelines, (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), efforts were made to ensure an equal, as possible, level of cognitive demands required for the implementation of each regulation strategy (reappraisal, distraction, suppression).

For all trials, subjects were requested to begin implementing each strategy, only after the image was displayed. In addition, they were asked to keep their eyes on the screen, throughout stimulus presentation and to avoid moving their eyes away from its emotionally salient features.

Each trial began with a white fixation cross (2 secs), projected in the center of a black screen, followed by an instruction cue of the upcoming trial (VIEW, WATCH, REAPPRAISAL, DISTRACTION, SUPPRESSION) for 2sec, and then by an image (presentation duration:5 secs), that took up about 85% of the screen (see trial structure of task below).

To facilitate subjects' transition from one trial to another, as well as their adherence to instructions, the instruction/cue screen and the background of the border of the upcoming image were colour-coded, based on instruction type, and, hence, regulation condition. More specifically, the colours for each instruction and analogous trial type were adapted by Truchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011 and were set as: grey for VIEW, black for WATCH, green for REAPPRAISAL, blue for DISTRACTION and yellow for SUPPRESSION.

At the end of each trial and following each image's presentation, subjects were asked to rate their level of valence and arousal to the depicted stimuli. Ratings for both variables were obtained on a 1-9 scale, based on the Self-assessment Manikin (SAM; Lang, 1980) measurement for IAPS stimuli (see note below).

For analyses, ratings of arousal were reverse-coded, such that higher values, indicated higher arousal levels.

Each of the six blocks, entailed 7 VIEW and 7 WATCH trials, along with 14 trials of one of three, each time, regulation strategies (either 7 REAPPRAISE, 7 DISTRACT, or 7 SUPPRESS). The abovementioned form of blocks was taken by Truchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011, with the aim of minimizing the possibility that participants would combine the use of strategies, and, thus, facilitating our objective of measuring each regulation strategy separately. This format was also in line with former ERP studies on emotion regulation strategies (Moser et al, 2009).

The sequence of the 28 trials within each block was separately randomized for each subject, and the order of the blocks was counterbalanced.

168 images (126 negative, 42 neutral) were selected from the International Affective Picture System (IAPS) (IAPS; Lang et al. 2008) [the 126 were taken from the initial task, after being standardized in a sample of undergraduate students, not included in the final participants' pool (see below more details of the standardization process and a list of the codes of all images included in the current study)].

Negative and neutral images differed in IAPs-derived ratings of normative valence (M = 2.37, SD = 0.65 for negative; M = 5.12, SD = 0.53 for neutral) and arousal (M = 5.95, SD = 0.77 for negative; M = 3.17, SD = 0.66 for neutral). These levels of images' valence and arousal are similar to previous electrophysiological studies that aim to measure the LPP component.

The 126 negative images were divided into three sets of 28 images and one set of 42 images (set A, B, C for the Regulation Strategies conditions and D for the WATCH condition), and were equated for valence, as well as arousal (p values for all > 0.6).

As the strength of the LPP, as a response to emotional images, has been found to be affected by the display of human features (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011), all sets of images were matched in terms of presence of human characteristics (A, B, C, D and neutral image set), χ^2 (3, N= 96) = .75, p = 0.86.

For piloting and standardization purposes, images were preliminary presented to a small pool of students, not included in the final sample of participants, by utilizing the Self-Assessment Manikin Scale (SAM; Lang, 1980), SAM (see below).

The task was administrated using E-prime 3 (Psychology Software Tools, Pittsburgh, PA) and participants were asked to remain seated about 20 inches away from the monitor.

Trial Structure **of the Explicit Emotion Regulation Task:**

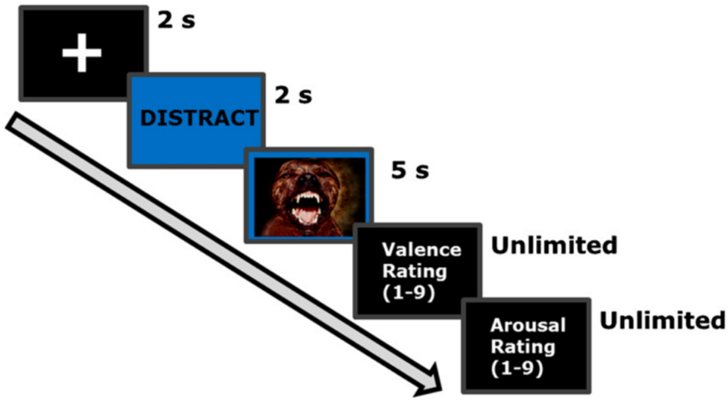


Fig. 1. Trial structure for the regulation task (an example of a DISTRACT trial).

[Taken by Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, (2011), p.87]

Note 1: The International Affective Picture System (IAPS) was developed by the Center for Emotion at the National Institute of Mental Health, at the University of Florida. It constitutes a standardized database of emotion-based coloured images designed for the scientific study of Attention and Emotion, that has been widely implemented in psychological research, world-wide. The IAPS database includes content from a wide range of semantic categories, with the total number of its images reaching 956, in 2005 (Lang, Bradley & Cuthbert, 2005).

Note 2: The Self-Assessment Manikin Scale (SAM; Lang, 1980) is a picture-oriented instrument that was developed by Lang (1980), in order to assess IAPS images, with reference to the dimension of valence, arousal, and the degree to which subjects feel that they have control (dominance) over the depicted affective stimulus. To this end, a figure / manikin (SAM) depicts a range of values, for each of the abovementioned variables (valence, arousal and dominance), on a continuous, ascending scale, with the aim of capturing subjects' individual emotional reactions to the presented, each time, affective stimuli (Lang, 1980; Bradley & Lang, 1994).

It constitutes a valid, non-verbal, and widely used self-report scale of emotional response, with high levels of reliability (both, within, and between subjects) (please find an illustration of the scale, below).

Self-assessment Manikin Scale (SAM; Lang, 1980)

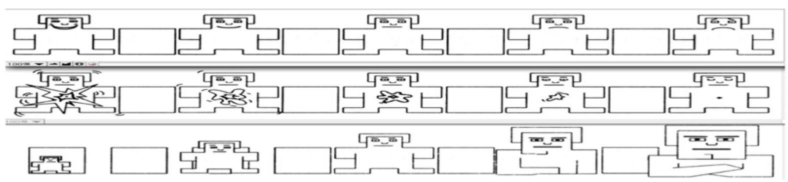


Figure 1. Example: Paper-and-pencil SAM booklet used to obtain SAM ratings for IAPS pictures in sets 1-6.

[Taken by Lang et al, 2005, p. 10].

Note 3:

Please find below the code of each image included in the current research - most of which have been taken from the original protocol of the aforementioned researchers (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011), while the rest have been selected and standardized, according to the specific criteria set by the initial researchers.

- *SET A – Condition "REAPPRAISE" (Negative Images):*

  1201, 2095, 2141, 2399,2710, 2750, 2800, 3064, 3100, 3101, 3140, 3550,6211, 6313,6315, 6350, 6510, 6550, 6555, 9250, 9252,9253, 9300, 9301, 9420, 9421, 9635.1, 9921.

- *SET B – Condition "DISTRACT" (Negative Images):*

  2120, 2130, 2375.1, 2683, 2691, 2810, 2900.1, 2981, 3000, 3010, 3015, 3120, 3130, 3160, 3400, 3530, 6212, 6230, 6243, 6570, 6821, 6831, 7359, 7380, 9050, 9265, 9405, 9410.

- *SET C – Condition "SUPPRESS" (Negative Images):*

  1220, 1280, 2053, 2301, 2352.2, 2703, 3001, 3059, 3061, 3071, 3103, 3063, 3185, 6200, 6213, 6300, 6520, 6563, 9043, 9075, 9140, 9163, 9180, 9321, 9332, 9430, 9500, 9592.

- *SET D – Condition "Watch" (Negative Images):*

  1050, 1111, 1300, 1930, 2700, 3030, 3051, 3053, 3060, 3168, 3181, 3220, 3230, 3300, 3301, 3350, 6415, 6830, 8230, 9006, 9040, 9042, 9181, 9433, 9570, 9571, 9800, 9810, 016, 3225, 3500, 6242, 6834, 6838, 8485, 9185, 9254, 9415, 9423, 9425, 9428, 9561.

- *SET E – Condition "VIEW" (Neutral Images):*

  2190, 2221, 2235, 2280, 2320, 2383, 2393, 2394, 2440,2480, 2495, 2516, 2560, 2579, 2580, 2749, 2840, 2850, 2870, 7025, 7090, 7175, 7211, 7217, 7493, 7496, 7550, 9210, 2102, 2191, 2200, 2214, 2377,2397,2515,2745.1, 5390, 5731, 5875,7012, 7041, 7061.

Implicit Emotion Regulation Task

Emotional Conflict Adaptation Task – Emotional Stroop (Egner, Etkin, Gale & Hirsch, 2008)

The task has been adapted and used with permission by Egner, Etkin, Gale & Hirsch (2008), and constitutes a variant of the classic Stroop paradigm (Stroop, 1935).

In this task, subjects were presented with black and white photographs of emotional faces (fearful or happy), on a black background, with an emotional word ("fear" or "happy") written over them, in red font. The specific word/label, either matched (no-conflict trial), or was incongruent (conflict trial), to the targeted picture (please see an example of the presented stimuli below). Subjects were then asked to identify whether the presented facial expression was happy or fearful, via key press.

Because reading is automatized (Stroop, 1935) during conflict trials, participants need to exhibit control over reading the word, in order to successfully identify the depicted emotional expression (Egner, Etkin, Gale & Hirsch, 2008). Consequently, conflict trials lead to greater reaction times, as it takes longer to respond to incongruent, compared to congruent stimuli (congruency effect). Implicit emotion regulation, in this task, is computed by subtracting changes in the congruency effect of the current trial, from the previous one (trial n-1). More specifically, conflict on trial n-1 seems to activate an anticipatory mechanism that leads to augmented emotional control, and hence, diminished susceptibility to emotional conflict on subsequent trial (trial n). As a result, response times in this task are overall faster to incongruent trials that occur after incongruent trails (iI) (high conflict resolution), compared to those preceded by a congruent trial (cI) (low conflict resolution) and this process has been found to develop outside of individuals' awareness (Gyurak et al, 2011).

The stimuli of the task consisted of a total of 5 male and 5 female faces, that the original researchers (Egner, Etkin, Gale & Hirsch, 2008) took from the standardized set of emotional faces, by Ekman and Friesen (1976). The words that express emotion and appear on the faces have been translated into Greek and stimuli has been adapted and used with permission. A total of 140 trials were included in the task and presentation order of stimuli (i.e. negative / positive, congruent / incongruent, etc.) was counterbalanced across subjects.

Stimuli were presented for 1000 ms, with a varying inter-stimulus interval of 3000-5000 ms (Mean interval = 4000 ms), during which a white fixation cross appeared on a black background, in the center of the screen.

Stimuli were presented in pseudorandom order (equal and counterbalanced order of congruent-incongruent, congruent- congruent, incongruent-congruent and incongruent - incongruent pairing/sequence of stimuli). Additionally, stimuli were counterbalanced with reference to gender of facial stimuli and depicted emotional expression. Provisions were made so that results were not affected by any other training factor (e.g. total or partial repetition), while the proportion of response repetitions, or response alternations, was equal (50%, throughout trials). No direct repetition of the same person with a different emotional-label on it appeared, in order to avoid any priming effects, nor direct repetitions of exact face-word distractor combinations occurred, so as to control for repetition-priming effects. Previous studies have demonstrated no category-priming effects of such tasks by repeating a specific category of facial expression (e.g. scared) and/or specific category of word (e.g.

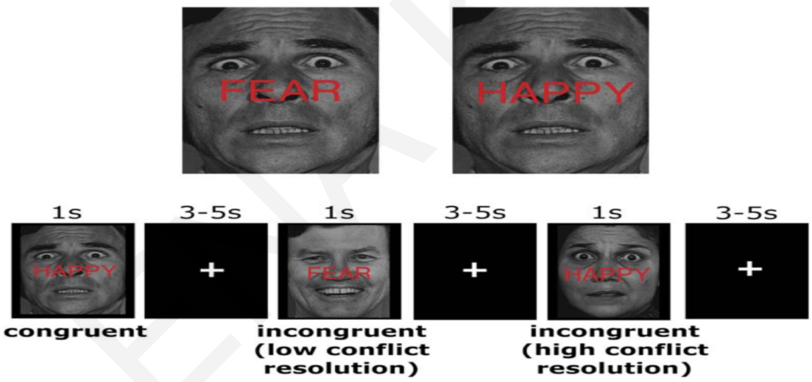
JOY) (Egner, Etkin, Gale & Hirsch, 2008).

E-Prime 3 (Psychology Software Tools, Pittsburgh, PA) was used for the design and implementation of this task and subjects were seated approximately ~20 inches away from the monitor and responded by pressing keys on a numerical keyboard.

Participants were asked to respond as quickly and accurately as possible, by pressing specific keys on the keyboard corresponding to the word "fear" (key number 2) or "joy" (key number 3), to identify the emotion expressed by the presented facial stimuli.

The analysis of behavioural data involved the obtainment of reaction times (excluding errors and post-error trials), as well as response accuracy for all conditions [congruent-incongruent (ci), congruent- congruent (cc), incongruent-congruent (ic), incongruent -incongruent stimuli (ii)], while implicit emotion regulation was estimated by comparing response times to incongruent trials that had occurred after an incongruent trial (iI), to those that had occurred after a congruent trial (cI) (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Gyurak et al, 2011).

Illustration of Task:



[Taken by:Etkin, Egner, Peraza, Kandel, & Hirsch, 2006, p. 872]

Study 1: The Relationship Between Emotion Regulation, Executive Functions and Psychopathology, A Confirmatory Factor Analysis

Purpose of Study:

To investigate the relationship between Exe*cutive Functions (EF), Emotion Regulation* (both implicit and explicit) and Psychopathology, via behavioural and psychometric measures. Towards this aim a Confirmatory Factor Analysis Model incorporating the specified constructs, was conducted.

For the purposes of the current project, the seminal work of Miyake et al., (2000), on the underlying factor structure of executive functioning that delineates *Shifting*, *Updating* and *Inhibition* as three interrelated, but empirically distinct components of executive functioning, was applied.

Theoretical Background

Previous Research on the Relationship Between Executive Functions and Emotion Regulation

Cognitive control processes have been proposed to hold a central role in emotion regulation by the most prominent neural models of ER (e.g. Ochsner & Gross, 2005; Ochsner & Gross, 2008; Ochsner, Silvers, & Buhle, 2012). Nonetheless, current research on the relationship between specific EF measures and ER ability, has yielded inconsistent results (e.g. Schmeichel & Tang, 2015; Gyurak et al, 2012; Pruessner, Barnow, Holt, Joormann, & Schulze, 2020).

In a comprehensive review of existing research, Schmeichel & Tang, (2015), cite 11 articles, describing 14 studies, on the relationship between individual differences in EF and successful ER ability. Overall, results supported a positive relationship between EF and ER, across diverse measures of both EF and ER and a range of ages, cognitive level and settings – laboratory and naturalistic (e.g. Stawski, Almeida, Lachman, Tun, & Rosnick, 2010). Working Memory capacity (WMC) constituted the most reliable predictor of ER (instructed and spontaneous), with evidence positively linking WMC to cognitive reappraisal and expressive suppression. Results have also been inconclusive with regards to the relationship between Emotion Regulation and, both, shifting and inhibition, with some studies reporting positive, and others reporting null (Schmeichel & Tang, 2015), or even negative (eg. McRae et al, 2012) corelations.

Among the studies reviewed, is the research conducted by McRae et al. (2012), who found that success in reappraisal was positively related to working memory capacity, and marginally to abstract reasoning, but not with verbal fluency or inhibitory control. Interestingly, this study found a positive relationship between reappraisal and set shifting costs, i.e. lower shifting ability.

In a similar vein, Schmeichel, Volokhov & Demaree, (2008), and Schmeichel & Demaree, (2010), found that WMC contributed to increased ability for suppression and reappraisal (instructed and spontaneous) (Tang & Schmeichel, 2014). Pe, Raes, & Kuppens, (2013), also reported a relationship between updating ability and reappraisal, both on a trait level (albeit, only for high arousal negative states) and in daily life, while a positive association between Working Memory Capacity and Emotion Regulation ability was also found, by Jasielska et al., (2015).

Across the same lines, Opitz, Lee, Gross, and Urry (2014) reported that fluid cognitive intelligence (as indexed by Working Memory, alongside with perceptual reasoning and processing speed) was associated with greater success in implementing reappraisal. Hendricks & Buchanan, (2016), also reported a positive correlation between WMC and negative affect reduction, during both reappraisal and suppression, with no clear, however, association between reduction in negative affect and response inhibition or set-shifting [albeit, both above mentioned variables being successful in predicting some aspects of emotional behaviour and regulation, as measured by corrugator electromyography, behaviour and self-report (ibid)].

Nonetheless, a few studies have failed to find a relationship between WMC and ER. For example, Gyurak et al., (2009; 2012), examined the relationship between four common measures of Executive Functions, (namely, working memory, inhibition, task switching and verbal fluency), and both instructed and spontaneous Emotion Regulation. Results indicated that only higher verbal fluency scores were related to greater ability to regulate emotion, in both conditions. No relationships were found between emotion regulation and other EF measures, including WMC.

With regards to the relationship between inhibition and emotion regulation, in one of the first studies to examine potential associations between measures of Executive Functioning and Emotion Regulation, von Hippel & Gonsalkorale, (2005), reported a positive correlation between inhibitory control and the suppression of socially inappropriate expressions of emotions. Similar results were reported by Tang & Schmeichel, (2014), who found a positive relationship between inhibitory control and suppression of subjective emotional responses.

More recently, Liang, Huo, Kennison & Zhoul (2017), reported a more central role of the mental ability of shifting towards reappraisal ability, compared to working memory capacity and/or inhibition in older adults. This effect was particularly significant for detached (i.e. taking the perspective of distanced observer), compared to positive reappraisal (i.e. ascribing a positive meaning to negative stimuli).

In the first study to examine the contribution of Executive Functions to Implicit forms of Emotion Regulation, Sperduti et al., (2017), reported a positive link between updating ability, but no other measure of EF (inhibition, shifting and WMC) and down-regulation of negative affect (nonetheless, this association was significant only for high, and not low, intensity material).

Emotion Regulation, Executive Functions and Psychopathology

Overall, compared to healthy controls, common deficits in cognitive control have been reported transdiagnostically, across a variety of disorders (e.g. Etkin et al., 2013; McTeague, Goodkind, & Etkin, 2016; Snyder, Miyake, & Hankin, 2015; Zelazo, 2020: offers a comprehensive recent review). On a structural level, common perturbations have been found in EF's and ER's (both explicit and implicit) brain circuitry (Etkin, Gyurak, & O'Hara, 2013).

Interestingly, in a recent metanalysis of structural neuroimaging studies across many psychiatric disorders, and namely DSM-IV Axis 1 Disorders, Goodkind et. al, (2015), found that dACC, an area significantly implicated in cognitive control, was one of the three areas exhibiting a reduction in grey volume in all disorders, irrespectively, and was related to poorer performance in executive function tasks, across disorders.

Extending this work, McTeague, et al, (2017) conducted a transdiagnostic neuroimaging meta-analysis and found a common pattern of disruption across major psychiatric disorders, within focal cognitive control areas, namely, the multiple-demand network, and its interface with the "salience" network, that is implicated in emotional processing. According to the authors, aberrant brain activation in both areas, could potentially, explain concurrent affective and neurocognitive deficits in psychopathology. Similarly, in a more recent neuroimaging analysis, the same research group identified common neural circuit disruptions across major psychiatric disorders, in core regions underlying emotional processing and regulation, that are also implicated in cognitive control (McTeague et al., 2020).

Similar disruptions are proposed by Menon's (2011) triple network model of psychopathology, which delineates aberrations in 3 core neurocognitive networks, as common features across multiple disorders: namely, 1) the Central Executive Network (CEN), implicated in cognitive control and working memory, 2) the "salience network", responsible for detecting salient external stimuli and internal brain events and thus, emotional processing and initiating engagement of cognitive control and motor regions via signalling, in order to activate goal-directed behaviour and 3) the Default Mode Network (DMN), responsible for self-referential mental activity, with some of its areas/nodes implicated in emotion regulation.

In a similar vein, in a recent metanalysis conducted by Sha, Wager, Mechelli & He, (2019), common disruptions in connectivity within and between neurocognitive networks implicated in cognitive control (the Default Mode Network, the Frontoparietal Network and the Salience Network) were found and were associated with grey matter reductions in regions subserving cognitive performance, across disorders. Furthermore, a recent meta-connectomic analysis conducted by the same research group revealed functional alterations, across investigated disorders, in regions including the vmPFC (implicated in Implicit and Explicit ER), the dlPFC (implicated in Explicit ER and Working Memory) and the motor cortex (Sha et al., 2018).

Adding to the above, recent dimensional approaches endeavouring to identify the structure and a general factor of psychopathology (the p factor) (Caspi et al. 2014; Lahey et al. 2012; Smith et al, 2020) (e.g. via a hierarchical or bi-factor model), have identified dispositional negative affectivity (Tackett et al., 2013), impulsive responsivity to emotion (Carver et al. 2017), thought dysfunction and low cognitive functioning (Caspi & Moffitt 2018; Caspi et al, 2014), high levels of disinhibition/impulsivity, negative emotionality and anxiety sensitivity, diminished response inhibition, performance IQ, (Castellanos-Ryan et al. 2016), as well as early poor childhood self-control, reflecting executive deficits and emotional dysregulation (Caspi et al, 2014), as underlying dimensions that might account for the common variance across general psychopathology. Endeavours have also been made to identify the structural neural correlates of the p factor (e.g. Romer et al, 2018; Elliott, Romer, Knodt, & Hariri, 2018), and have identified hyperactivation between the visual association cortex and areas implicated in executive control and self-referential processes (namely, frontoparietal and default mode networks).

Methodology

For the purposes of the current study, behavioural and self-reported measures of the entire sample of the current thesis (N=120), on all implemented experimental tasks and psychometric instruments, were utilised. More specifically, behavioural and self-reported measures were utilised by the research's following tasks and instruments (described in detail, in the current thesis's Methodology Section):

Experimental Tasks

- Executive Function Tasks:
  - *Inhibition*
    1.Antisaccade (Hallett, 1978)
    2. Stroop Task (Stroop, 1935)

- *Shifting*
    1. Number-Letter (Rogers & Monsell, 1995)
    2. Category Switch (Mayr & Kliegl, 2000)
- *Updating*
    1. Keep Track (Yntema, 1963)
    2. Letter Memory (Morris & Jones, 1990)

- *Emotion Regulation Tasks*

1. *Explicit Emotion Regulation Task* (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011)
    - Self Reported measures of changes in valence and arousal to presented affective stimuli, after the implementation of each instructed Emotion Regulation strategy (Reappraisal, Suppression, Distraction).
2. *Implicit Emotion Regulation*
    - Emotional Conflict Adaptation task – Emotional Stroop (Egner, Etkin, Gale & Hirsch, 2008)

Psychometric Instruments

- *Psychopathology*
    1. Psychiatric Diagnostic Screening Questionnaire (PDSQ) (Zimmerman & Mattia, 2001)
    2. Symptom Checklist-90-Revised - Psychopathology Scale (Derogatis, 1994)
- *Emotion Regulation*
    1. Difficulties in Emotion Regulation Questionnaire (Gratz & Roemer, 2004)
        - Subscales: Awareness, Clarity, Impulse, Goals, Acceptance and Strategies.
    2. The Emotion Regulation Questionnaire, (Gross & John, 2003)
        - Subscales: Reappraisal and Suppression.

Data were initially analysed in SPPS, via the conduction of a Correlation analysis, in order to examine potential significant correlations, indicative for further analysis. Mplus 8.4 (Muthén, & Muthén, 1998-2017), was then utilised for the conduction of the study's Confirmatory Factor Analysis. Modification indices, as well as Exploratory Factor Analysis were also utilised in order to conclude to the final model, as certain indicators (namely, for the construct of Emotion Regulation), did not initially fit the model as expected.

Prior to analysis, the data were evaluated and treated for univariate and multivariate outliers. SPSS's Multiple Imputation function was implemented in order to handle missing data. To account for diversity in measures, z-scores of all dependent measures were used. In addition, for the purposes of the correlation analysis, variables which consisted of measures obtained by two tasks (namely, Working Memory, Inhibition and Shifting), were computed into averages (i.e. both measures for each variable were utilised for computing an average of the specified variable, in SPSS). In addition, an overall average of ER ability was estimated, for the purposes of the correlational analysis, by combining/computing values from all individual ER strategies (Reappraisal, Suppression, Distraction). Consequently, both separate values for each strategy, as well as computed overall ER ability, were used for the correlational analysis. Lastly, instruments measuring psychopathology were individually scored (indicative clinical cut-off scores were used) and values 0 = no affective disorder and 1 = existence of affective disorder, were subscribed to each participant, for each instrument, separately (i.e. a binary variable was computed for each participant, for each scale). Affective disorders for the current thesis were, according to literature (e.g. Bullis et al., 2019), defined as Mood and Anxiety disorders.

The results from each abovementioned analysis (Correlational and Confirmatory Factor Analysis) are described in the following sections.

Results

Correlational Analysis

Significant correlations were reported among Executive Function Tasks. More specifically, Inhibition presented a significant, albeit moderate, positive correlation with both Updating (r=.276, p<0.05) and Shifting (r=.376, p<0.05). Nonetheless, the correlation between Updating and Shifting was only marginal significant, for one of the two measured tasks (namely, only the letter memory task correlated with Shifting, r= .166, p=0.07).

With regards to the relationship between EF Tasks and explicit ER Strategies, the function that exhibited the strongest correlation with behavioural measures of overall ER ability was Updating. More specifically, Updating had a positive, statistically significant, relationship with overall explicit ER ability, as indexed by a reduction in both the arousal (r=.225, p<0.05) and valence (r=.182, p<0.05) of the negative affective material presented during the explicit ER task, while implementing ER strategies. When measuring the unique correlation of Updating with each ER strategy, this relationship was significant for Reappraisal (r=208, p<0.05 for arousal and only marginally significant for reappraisal's valence, r=.163, p=0.08) and Suppression (r=181, p<0.05 for arousal and only marginally significant for suppression's valence, r=.166 p=0.07).

As for the relationship between Shifting and ER, a significant correlation was reported between the specified function and psychometric measures of ER and, more specifically, the ERQ self-report questionnaire. This relationship was, surprisingly, negative for the Reappraisal subscale ($r=-320$, $p<0.05$) and positive for the Suppression Subscale ($r=180$, $p<0.05$). With regard to the relationship between Shifting and behavioural measures of ER strategies, a significant positive relationship was reported for Suppression ($r=.186$, $p<0.05$ for arousal), and a marginally significant negative relationship was reported for distraction, although only for one of the two tasks measuring Shifting, and namely, Number-Letter ($r=- 167$, $p=0.07$, for arousal).

A positive and significant relationship was reported between behavioural measures of overall ER ability and the EF of Inhibition, as indexed by a decrease of negative valence on the ER task ($r=196$, $p<0.05$). Also significant, and in a positive direction, was the relationship of Inhibition with the strategy of Reappraisal, separately, ($r=235$, $p<0.05$ for valence and marginally for arousal for the Antissacade task only, $r=.179$, $p=0.051$), while it was marginally significant for the strategy of Distraction ($r=.164$, $p=0.07$, for valence in relation to the Stroop task, only).

With regard to psychometric measures of ER and their relation to EF, a significantly negative relationship was reported only between the Antisaccade task measuring Inhibition and the Suppression Subscale of the ERQ Self-Report Questionnaire ($r= = 219$, $p<0.05$).

As expected, Implicit ER ability, as measured by the Emotional Stroop Task, was not significantly correlated with performance on EF tasks.

It is worth mentioning that psychometric measures of ER ability, as obtained by the self-report ERQ and DERS questionnaires, did not present a correlation with the behavioural measures of ER Strategies and ability (albeit, a paradoxical positive correlation between the ERQ's reappraisal subscale, and behavioural measures of Suppression, even though this relationship was marginal and thus, nonsignificant [$r=.169$, $p=0.06$ for arousal]). As for the relationship between DERS and ERQ, this was positive for the Suppression Subscale ($p=.188$, $p<0.05$) and strongly negative for the Reappraisal Subscale (-458, $p<0.05$).

As for the relationship between potential clinical symptomatology, as measured by SCL-90-R and PDSQ, and ER ability, this was significant both for the psychometric, as well as the behavioural self-reported measures of ER. More specifically, scores on both the SCL-90-R and the PDSQ demonstrated a significantly negative correlation with ERQ's Reappraisal subscale [($r = - . -272$, $p < 0.05$) and ($r = - . -199$, $p < 0.05$), respectively]. The relationship between both questionnaires assessing for potential psychopathology and difficulties in ER, as assessed by the DERS self-report psychometric instrument, was also statistically significant and with a positive direction ($r=508$, $p <0.05$ for SCL-90-R and $r=453$, $p<0.05$ for PDSQ).

Behavioural measures of the ER strategy of Reappraisal were significantly correlated only with the SCL-90-R questionnaire ($r = - .231$, $p < 0.05$), while behavioural measures of Suppression, were only marginally correlated with PDSQ ($r=.152$, $p=0.09$, for arousal). The relationship between psychometric measures of ER and psychopathology was significantly negative between both instruments screening for potential clinical Symptomatology (SCL-90-R and PDSQ) and ERQ's Reappraisal subscale (namely, $r=-272$, $p<0.05$ for SCL-90-R and $r=-199$,$p<0.05$ for PDSQ) and positive, though marginally significant, between SCL-90-R only and ERQ's suppression subscale ($r=.165$, $p=0.07$).

With regard to the relationship between potential Psychopathology and Executive Functions, the only reported relationship, though also marginally significant, was between PDSQ and Inhibition ($r=153$, $p=0.09$)

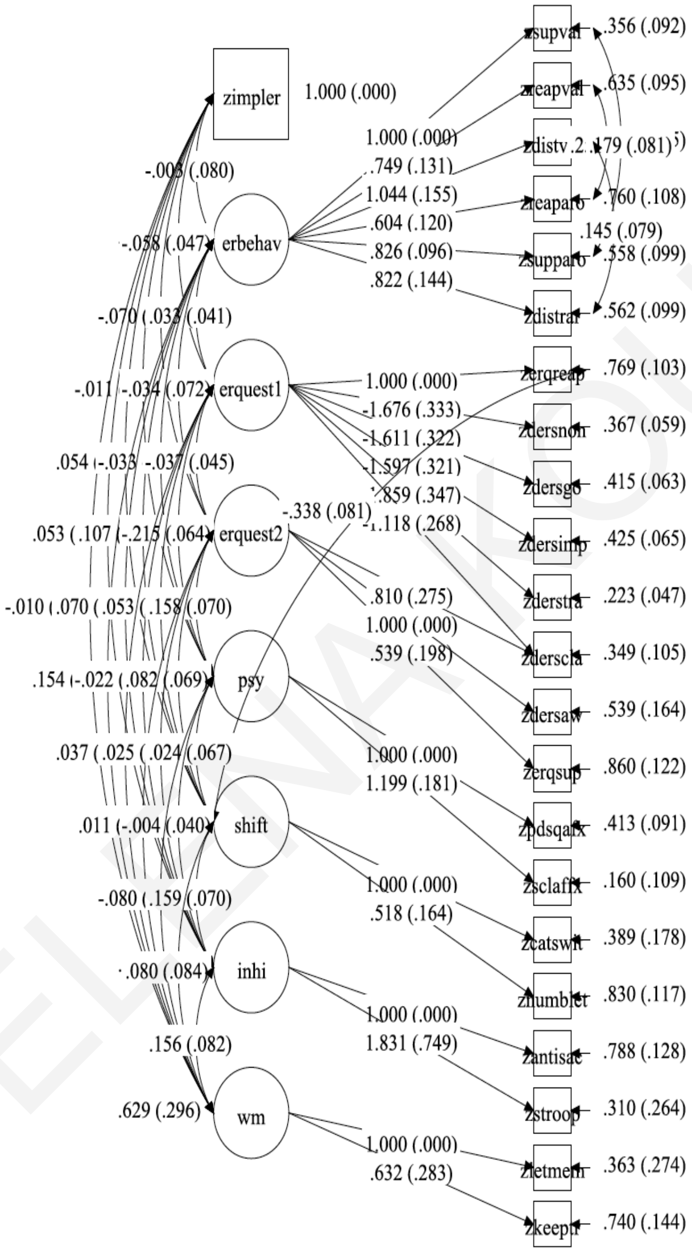
Finally, even though, again, marginally significant and week, the relationship between the psychometric instrument screening for potential psychopathology PDSQ and Implicit ER ability was positive (r 162= $p = 0.08$) [See ***Table 2*** with Study's 1 Significant and marginally significant correlations - Appendix].

Results from Confirmatory Factor Analysis and Exploratory Analysis

Based on prior literature on the relationship between Emotion Regulation, Executive Functions and Psychopathology, a 7-factor model was specified: 3 for Executive Functions (Inhibition, Shifting, Updating), 1 for Psychopathology, 1 for behavioural measures of explicit Emotion Regulation, and 2 for psychometric measurements of Emotion Regulation (ERQ's reappraisal subscale and DERS's Acceptance, Goals, Impulse, Strategies, and Clarity subscales constituted the first factor, while the second was composed of ERQ's suppression subscale, alongside DERS's Awareness and Clarity Subscales). Behavioural measures on the Emotional Stroop task (Egner, Etkin, Gale & Hirsch, 2008) were also added as a Single Indicator of Implicit Emotion Regulation. [Please see ***Table 3*** for each's Variable's Indicators and Metrics - Appendix]. ***Figure 4*** depicts the complete specification of the seven-factor and single-indicator model.

The measurement model contained only one double-loading (DERS's Clarity Subscale loaded on both Latent Factors of Emotion Regulation psychometric measures). All measured error was presumed to be uncorrelated, apart from the one relating to Implicit Emotion Regulation. Since the latter was assessed by a single indicator, according to proposed guidelines (Muthén, & Muthén, 1998-2017; Brown, 2015), error for this variable was predetermined (i.e. fixed to a specific value). All latent variables were permitted to be correlated, based on prior evidence of a relationship between the specified dimensions, while correlations were also requested among each one and Implicit Emotion Regulation, separately. Further analysis of the model confirmed that it was identified.

Figure 4: Study 1's Confirmatory Factor Model for the Constructs EF, ER and Psychopathology



As noted in the "Method" section, all tasks and measures were administered to 120 University students, who voluntarily participated in the study (see "Method" for description of sample demographics). Prior to the CFA analysis, the data were evaluated and treated for univariate and multivariate outliers. SPSS's Multiple Imputation function was implemented in order to handle missing data. Normality of the indicators was also examined and confirmed. To account for diversity in the metrics of the indicators, as well as for binary variables (namely, indicators used for Psychopathology), z-scores of all dependent measures were used.

The sample variance–covariance matrix was analysed with Mplus 8.4 (Muthén, & Muthén, (1998-2017), and the Maximum Likelihood estimator was utilized, as data was treated as continuous (significant correlations are listed above and are presented in ***table 4***).

Goodness of fit was evaluated by using the standardized root mean square residual (SRMR), the root mean square error of approximation (RMSEA) and its 90% confidence interval (90% CI) (CFit), the comparative fit index (CFI), and the Tucker–Lewis index (TLI).

Based on literature-based guidelines on Goodness-of-Fit Indices (Brown, 2015; Hoyle, 2012; Geiser, 2012), acceptable model fit was defined by the following criteria: RMSEA (≤ 0.06, 90% CI ≤ 0.06), (SRMR (≤ 0.08), CFI (≥ 0.95), and TLI (≥ 0.95), χ^2 of Model Fit, $p>0.05$

Each of the overall goodness-of- fit indices suggested that the confirmatory-factor-model fit the data well: SRMR = .056, RMSEA = .054 (90% CI = 0.036–. 070), TLI= 0.907, CFI = 0.926 (even though the criterion for a non-significant χ^2 was not meant, [χ^2 (199) = 13.285, p = .001] this, in accordance to proposed literature-based guidelines, was compensated by the adequate alternative model fit indices). Inspection of standardized residuals and modification indices indicated no localized points of ill fit in the solution. It is worth noting that modification indices were used, in order to conclude to the final form of the model, while Exploratory Factor Analysis was also conducted for the Construct of Emotion Regulation, as indicators did not initially fit the model as expected (e.g. arousal and valence were expected to load onto separate factors, even though Exploratory Factory Analysis suggested otherwise). The final grouping of each questionnaire's subscales was also suggested by Exploratory Factor Analysis. Unstandardized and completely standardized parameter estimates from this solution are presented in ***Table*** 5 and ***Table 6***. All freely estimated unstandardized parameters were statistically significant ($p < .001$). Factor loading estimates revealed that the indicators were strongly related to their purported factors (ranges between .363 – .912).

The Findings of the Model that were significant can be summarised as follows:

- Miyake's et al's (2000) model of Executive Functions was overall replicated. Inhibition was correlated with Shifting (r=150, p<0.05) and Updating was marginally correlated with Inhibition (r=.156, p=0.059). No significant relationship was reported between Updating and Shifting.

- All behavioural Measures of ER loaded on the same Factor (as suggested by preliminary Explanatory Analysis), even though they represented diverse ER strategies (i.e. Reappraisal, Distraction and Suppression) and even though they contained diverse measures of affective value and, thus, diverse measures of the structure of emotion (namely, arousal and valence).
- Behavioural and Psychometric measures of ER ability loaded on distinct Factors. Interestingly, Exploratory Factor analysis indicated that ERQ's reappraisal's subscale loaded on the same factor with DERS's Acceptance, Goals, Impulse, Strategies, and Clarity subscales. The latter (DER'S Clarity Subscale), also loaded on the second factor, alongside with the remaining subscales of the administrated ER psychometric instruments (namely, ERQ's suppression subscale and DERS's Awareness subscale.
- All psychometric measures of Emotion Regulation Ability correlated significantly with the Latent Factor of Psychopathology (r= -215, p<0.05 for ER Psychometric Measures 1 and r=.158, p<0.05 for ER Psychometric Measures 2).
- The Executive Function of Shifting had a significant negative correlation with ERQ's Reappraisal Subscale (r=-338,p<0.05)
- Updating ability had a marginally significant correlation with behavioural measures of ER ability (r=.154, p<0.059).
- No significant relationships between Implicit ER and other constructs were reported. Nonetheless, Implicit ER was represented by a single indicator, and thus, methodological constrains restrain the possibility of extracting further conclusions with confidence.

Discussion of Significant Results of Study 1 – Combining results from Correlational, Exploratory and Confirmatory Factory analysis

The purpose of the current study was the examination of the relationship between three constructs: Executive Functions, Emotion Regulation (Explicit and Implicit) and Psychopathology, through a range of behavioural and psychometric measures. For the purposes of the current study, Confirmatory Factory Analysis was conducted, following the preliminary conduction of a correlational and Exploratory Factory Analysis.

The results of the current study point towards the existence of a relationship between Executive Functions and Emotion Regulation, even though - and in convergence with existing literature, this relationship differed for each measured variable.

It is worth noting, firstly, that the present study replicates Miyake et al.'s, (2000), Confirmatory Factory Analysis on the Unity and Diversity of Executive functions, which delineates Inhibition, Shifting and Updating as robustly correlated, but separable latent variables. Interestingly, the findings of the present study also align with more recent revisions of their initial theoretical model (Friedman & Miyake, 2017), as the original proponents of the model have now introduced a hierarchical, bifactor model, which involves a common EF latent variable, together with updating and shifting. The Common EF factor seems to account for all correlations among inhibiting tasks, and, thus, inhibition is no longer extracted as a separate factor [several researchers have interpreted this as either evidence that inhibition constitutes the most central Executive Function, or as evidence against there being something special about Inhibition (Friedman & Miyake, 2017)]. This declaration might also explain why, in the present study, a relationship was found between Inhibition and all two remaining constructs, but not among Shifting and Updating.

As for the relationship between Executive Functions and Emotion Regulation, the Function that exhibited a correlation with overall behavioural measures of ER (even though marginal for the Confirmatory Factory analysis and significant only for the initial correlational analysis), was Updating. This finding is in line with a plethora of research linking Working Memory Capacity (WMC) to Emotion Regulation Ability (Opitz, Gross, & Urry, 2012; Schmeichel, Volokhov, & Demaree, 2008; Schmeichel & Demaree, 2010; Pe, Koval, Houben, Erbas, Chambpagne, & Kuppens, 2015; Jasielska et al, 2015; Coifman et al, 2019), despite previous findings being inconsistent (e.g. Gyurak et al., 2009; 2012). For instance, with regard to reappraisal, apart from recruiting common brain areas, (Lee & Xue, 2018), the specified strategy and in general cognitive change, is hypothesised to recruit working memory resources, in an effort to utilise internal models and attribute a different meaning to a situation (Etkin, Büchel & Gross, 2015). Furthermore, deficits in controlling the contents of working memory may affect successful emotion regulation, since the experience of a mood state, or an emotion, is connected with the activation of mood-congruent representations in working memory (Joormann & Vanderlind, 2014) and may underlie an inability to disengage from rumination, in various affective disorders. Similarly, stress has been found to impair WM and dlPFC function and reappraisal ability (Etkin, Büchel , & Gross, 2015), while high WMC acts in a way that protects against stress's negative effect on individual cognitive ability (Ottoa, Raiob, Chiang, Phelpsa, & Dawa, 2013).

It is also worth noting that, inhibition exhibited a positive correlation with behavioural measures of ER (reappraisal and distraction) and psychometric measures of ER (namely, ERQ's suppression subscale) in the correlational analysis, and an even more marginal (compared to updating) relation in the Confirmatory Factor Analysis (p=0.09). This, again, is in convergence with previous research documenting the significant role of inhibition in ER ability (Von Hippel & Gonsalkorale 2005; Tang & Schmeichel, 2014), and subsequently, mental health (Joormann & Gotlib, 2010).

Surprisingly, a significant correlation was reported between the Executive Function of Shifting and ERQ's Reappraisal Subscale. Even though counterintuitive at first sight, the proposed relationship in the model was suggested by modification indices, and adding the specified correlation, improved the fitness of the model, to a significant extent.

Interestingly, a negative relationship between shifting and reappraisal was also found by McRae et al., (2012), who found that greater reappraisal success was positively correlated with increased set-shifting costs. Even though high levels of set-shifting costs could have been indicative of diminished shifting ability, this finding was also accompanied by increased accuracy on shifting tasks. Hence, the authors interpreted this result as indicative of the participants' endeavour to prioritize accuracy over speed, and in turn, as an index of cautious strategy implementation.

In the ER literature, the cognitive ability of shifting has been linked to the concept of Emotion Regulation Flexibility (ERF) (Aldao, Sheppes, & Gross, 2015), which is defined as the ability to ongoingly adapt emotion regulation strategies to dynamically changing contextual demands and goals (Aldao et al, 2015; Pruessner et al, 2020). ERF has overall been linked to greater positive outcomes, in terms of efficacy in implementing ER strategies, and consequently, with positive mental health outcomes and overall wellbeing. It has also been proposed to underly the identification, selection, and implementation stages (with reference to ER strategies) outlined in Gross's (2015a) Extended Process Model, and especially, the processes of stopping or switching strategies (Pruessner et al, 2020), when appraised as maladaptive. However, despite its documented positive role, ERF, might not always be adaptive (Aldao et al, 2015; Pruessner, 2020) and, especially, when it interferes with the pursuit and maintenance of personal goals (Aldao et al, 2015; Pruessner, 2020; Dreisbach & Fröber, 2019). The activation and maintenance of goals (and of course their appropriate alteration, in accordance to contextual demands and/or personal appraisals of these [goals]) is a significant proposition of reappraisal (Uusberg et al., 2019). As such, reappraisal might not rely so much, or even deviate from shifting ability, as it is related with stable goals to increase positive affect and decrease negative affect and, hence, requires an amount of stability and goal maintenance (Uusberg et al., 2019). Indeed, the indispensable need of focusing on current task demands and goals, might underly the central role of updating in reappraisal (Pruessner, 2020) and explain deficits in maintaining ER strategies and strategic stability exhibited in an array of mental health disorders (e.g. bipolar disorder) (ibid).

What is more, reappraisal requires advanced cognitive processing and more complex mental models, in order to reach an abstract representation of how a situation is construed, compare it to potentially diverse or changing goals and accordingly, alter its construal or goal set (dynamic, inter-related processes termed by Uusberg et al, 2019 as reconstrual and repurposing, respectively). As such, it also demands sustained attention towards affective stimuli, while the subjective affective state itself might also render itself as the object of attention [this might be especially true for mindful acceptance, which has been proposed by some researchers to constitute a form of reappraisal (ibid)]. This, in turn, might denote that reappraisal and suppression (the latter being more correlated to the concept of experiential avoidance), operate by reverse/competing mechanisms, while they, provenly, target different time points of the emotion generation process (Gross,1998a; 2015a). Therefore, reappraisal's negative relationship with shifting in the proposed Confirmatory Factor Analysis model, might as well reflect a negative relationship between habitual reappraisal and suppression, as the latter was found to corelate positively with shifting, in the preliminary correlational analysis. Indeed, across numerous studies exploring the factor structure of the Emotion Regulation Questionnaire, each of the two subscales (reappraisal and suppression) loads on separate factors (e.g. Preece et al, 2019; 2021). Therefore, exploring and delineating potential mediating or moderating effects between the reported negative correlation between shifting and reappraisal will further elucidate this finding.

It is also worth noting that, reappraisal has further been distinguished in positive reappraisal (i.e. reinterpretating a situation), or detached/perspective -taking (i.e. analysing the situation objectively, from a detached observer's perspective) (Liang et al, 2017; Uusberg et al, 2019). The ERQ's reappraisal questionnaire's items seem to greater represent the first type of reappraisal, and as such the negative relationship found between thus subscale with shifting might not hold for the second type [in parallel to this, Liang et al, (2017), found that detached reappraisal relied more heavily on set shifting, compared to positive reappraisal]. Lastly, the questionnaire captures the habitual/more automized use of reappraisal in daily life, and as such did not access online cognitive functioning, while implementing reappraisal, which might also account for the negative relationship observed (supporting this assumption, is the fact that behavioural measures of reappraisal did not exhibit a negative correlation with shifting).

An interesting again finding, related to the above, was the proposed factor loadings of the psychometric measures of ER ability, by Exploratory Analysis. More specifically, Exploratory Factor Analysis indicated that ERQ's Reappraisal subscale loaded on the same factor with DERS's Acceptance, Goals, Impulse, Strategies, and Clarity subscales, while the latter (DER'S Clarity Subscale), also loaded on the second factor, alongside with the remaining subscales of the administrated ER psychometric instruments (namely, ERQ's Suppression subscale and DERS's Awareness subscale). Even though none, to my knowledge, confirmatory factory analysis studies has combined both instruments up to now, previous CFA models conducted on the DERS questionnaire, demonstrate diverse factor loadings of each of its subscales [with some researchers confirming the initial factor model with the proposed 6 subscales e.g. Perez et al, (2012), and some, suggesting a better fit when the subscale of Awareness is omitted, and thus, entails only five factors e.g Bardeen, Fergus & Orcutt, (2012)].

Nonetheless, the proposed classification of both instruments - as also validated through subsequent Confirmatory Factor Analysis, appears theoretical meaningful, with the first grouping reflecting more adaptive forms of viewing, appraising, and regulating affective experiences, while the second grouping seems more akin to the construct of experiential avoidance, were a lack of awareness and clarity of emotions leads to suppression of experienced and/or expressed affect. The awareness and clarity subscales of the DERS questionnaire instrument have been found to jointly be classified under the overall ability for emotion recognition (Naragon-Gainey, McMahon,& Chacko, 2017), while in a study trying to explore the structure of Emotion Regulation (Seligowski & Orcutt,2015), a common factor labelled "emotional distancing" , which consisted of thought suppression, acceptance, and experiential avoidance, was also identified [although the specified study did entail many methodological constrains, Naragon-Gainey, McMahon,& Chacko, (2017)]. Across the same lines, Naragon-Gainey, McMahon,& Chacko, (2017), conducted an Exploratory and Confirmatory analysis, in order to examine the underlying structure of common emotion regulation strategies. Even though, again, the study presented several methodological limitations, Naragon-Gainey, McMahon,& Chacko, (2017), did identify a common factor labelled Disengagement, which consisted of low mindfulness, behavioural avoidance and experiential avoidance, and expressive suppression. Being able to experience (opposite of suppression) and identify and differentiate the full range of emotions (awareness and clarity) are considered as indispensable for adaptive emotion regulation

(Gratz & Roemer, 2004) and have been recently related to Barret's, (2017), concept of Emotional Granularity, also referred to as "emotion differentiation", which denotes an individual's ability to create and differentiate with precision, instances of emotion that are diverse and context-specific (i.e "the number emotion categories an individual's brain can create, as well as greater situated variation in the instances belonging to those categories" Hoemann et al. in press , p.3).

Surprisingly again, and also in accordance with loadings suggested by preliminary Exploratory Analysis, all behavioural measures of the emotion regulation strategies implemented in the Explicit Emotion Regulation task loaded on a common factor. This was despite the divergence in terms of their position in the temporal process model proposed by Gross (2015a), and also despite the specified variables consisting of, phenomenologically, at least, diverse measures of the construct of emotion, namely, valence and arousal. Nonetheless, again this was not inconsistent with existing literature.

More specifically, as mentioned above, a number of studies (albeit, very scarce) have up to now endeavoured to study the structure of emotion regulation strategies (Aldao and Nolen-Hoeksema, 2010; Seligowski & Orcutt, 2015; Lee et al, 2015; Naragon-Gainey et al, 2017). Classification has been attempted either: 1) based on temporal-processed theoretical models, such as Gross's (2015a), 2) categorising strategies as adaptive (e.g. acceptance, problem solving, reappraisal, mindfulness), or maladaptive (e.g. expressive suppression, experiential avoidance, behavioural avoidance, rumination) and/ or in line with dispositional abilities proposed to facilitate successful emotion regulation, such as the ones proposed by Gratz & Roemer's (2004) model (DERS) and 3) by discriminating among cognitive and behavioural strategies. Therefore, an enormous variety and overlap of how Emotion Regulation strategies might be classified, exists. Nonetheless, to my knowledge, none of the existing studies have, up to now, achieved good model fit, which, to an extent, relates to methodological restrains (e.g. limited number of indicators or confounded measure-specific variance).

Furthermore, the current scientific literature lacks agreement on whether arousal and valence constitute related or independent constructs (Kuppens et al, 2013). Neuroscientists have tried to make this distinction on a brain level as well, though, results have been inconsistent across studies, and even meta-analytic studies demonstrate variability (ibid). However, there is some considerable consensus that arousal takes on a V-shaped, in relation to valence relation (i.e. arousal equals the intensity or extremity of positive and negative valence), in the domain of affective ratings of visual scenes (Lang, 1994; Kuppens et al, 2013), such as in the case of affective stimuli implemented in the present study's experimental ER task. Nonetheless, the seemingly common variance of valence and arousal might, as well, reflect participants' difficulties in differentiating among both constructs, when conducting their appraisals (again, related to Barret's, 2017, concept of Emotional Granularity), and/or even mistakes in coding their ratings on the given scales, and, therefore, attributed to methodological limitations i.e. erroneous coding.

No significant relationship was found among Executive Functions and behavioural measures of Implicit ER, as obtained by the Emotional Stroop Task (Egner, Etkin, Gale & Hirsch, 2008), which confirms existing evidence about the involvement of potentially distinct neural networks (Etkin, Gyurak, & O'Hara, 2013). This finding, nonetheless, diverges from the one by Sperduti's et al, (2017), who found a positive relationship between implicit emotion regulation and updating ability (even though only for high, and not low, intensity material). However, as underlined, Implicit ER was represented by a single indicator, and, thus, methodological constrains preclude the drawing of any firm conclusions (nonetheless, the absence of a correlation among the two abovementioned constructs was also evident in the preliminary correlational analysis).

As far as the relationship between symptoms relating to psychopathology and Emotion Regulation is concerned, this was found significant for all psychometric measures of ER, which confirms existing literature regarding the focal role of ER, in the development and maintenance of psychopathology (Etkin et al., 2013; McTeague, Goodkind, & Etkin, 2016).No significant relationships were found between EF and Psychopathology or Implicit ER and Psychopathology (despite marginally significant relationships found in the correlational analysis). Nonetheless, results need to be interpreted with caution, given certain methodological constrains (i.e. single indicator for Implicit ER and diversity of metrics for all measured variables).

Study 2 and Study 3: ERP Studies of the relationship between Explicit and Implicit Emotion Regulation, Executive Functions and Psychopathology

The aim of Study 2 was to obtain electrophysiological measures of each Explicit Emotion Regulation Strategy studied, as measured by the research's Explicit Emotion Regulation Task (Truchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), and examine their relationship with behavioural measures of Executive Functions and Implicit Emotion Regulation, as well as psychometric measures of psychopathology (namely, SCL-90-R and PDSQ). In a similar vein, the aim of Study 3 was to obtain electrophysiological measures of Implicit Emotion Regulation, as measured by the Emotional Conflict Adaptation Task

(Egner, Etkin, Gale & Hirsch, 2008) and investigate their relationship with behavioural measures of Executive Functions and psychometric measures of psychopathology (SCL-90-R; PDSQ).

For organisational purposes, an introduction into relevant literature on the use of ERP measures in Emotion Regulation, as well as the overall methodology implemented for the collection and analysis of ERP data for both studies, are presented in the following section. The individual aim and results for each study will, subsequently, be presented separately.

ERP Studies of Emotion Regulation

Event-related potentials (ERPs) are thought to reflect synchronous electrocortical activity of populations of neurons - in particular, summated post-synaptic potentials (Luck, 2005), time-locked to an event (e.g, stimulus onset). Distinguished by their exceptional temporal resolution, scalp topography, ability and responsiveness to experimental manipulations, ERPs constitute an ideal method for measuring neural processes and dynamics related to emotion and emotion regulation (Hajcak, MacNamara, & Olvet, 2010).

Two of the ERP components that are most prominently used in emotion regulation research are the Late Positive Potential (LPP; an index of sustained attention to, and processing of emotional stimuli) and the Error-related Emotion Regulation Negativity (ERN; an electrophysiological correlate of performance monitoring) (Hajcak, MacNamara, & Olvet, 2010; Seeley, Garcia, & Mennin, 2015). For the purposes of the current research proposal, the Late Positive Potential (LPP), will be more extensively presented.

Late Positive Potential

The LPP (Late Positive Potential) constitutes a midline centroparietal ERP with a rather sustained positive deflection that becomes evident around 300 ms post stimulus presentation (Hajcak, Weinberg, MacNamara, & Foti, 2012; Speed, & Hajcak, 2020; Hajcak, & Foti, 2020). The LPP is thought to arise from reciprocal activation of frontal and occipital-parietal regions (Moran, Jendrusinab, & Mosera, 2013). The LPP appears to be larger following the presentation of both pleasant and unpleasant, compared to neutral stimuli and evidence indicates that an increased LPP persists throughout the duration of stimulus presentation, indexing sustained attention to emotional stimuli (Hajcak & MacNamara & Olvet, 2010). The magnitude of the LPP seems to be associated with subjective ratings of emotional arousal, as well as stimuli’s motivational salience. Furthermore, the amplitude of the LPP increases more towards stimuli with a biological survival valence (Hajcak, Weinberg, MacNamara, & Foti, 2012).

The time frame, as well as the amplitude of the LPP, constitute a significant index of response to emotional stimuli. The increase of the LPP towards emotionally stimuli, compared to neutral, has been found to be greater for the most emotionally intense stimuli (either positive or negative). Furthermore, the LPP seems to be independent of the size or perceptual characteristics of the stimulus (Hajcak & MacNamara, & Olvet, 2010). Nonetheless, in contrast to amygdala activation that can be recorded even in the presence of implicitly presented affective stimuli, existing data shows that activation of the LPP requires conscious identification of emotional stimuli (Hajcak, MacNamara, & Olvet, 2010).

Most importantly, increase in the LPP in response to emotional, rather than neutral stimuli, doesn't seem to be affected by habituation from repeated stimulus presentation, compared to other measures, which seem to be sensitive to emotional compared to neutral stimuli, such as skin conductance, heart rate, facial muscle activity and amygdala activation measured using fMRI (Hajcak, Weinberg, MacNamara, & Foti, 2012).

What is more, the LPP appears to be relatively stable over time within subjects (Hajcak, Weinberg, MacNamara, & Foti, 2012). Research indicates that there is no indication that concurrent task difficulty itself reduces the emotional modulation of the LPP (Hajcak, MacNamara & Olvet, 2010). Interestingly, the emotional modulation of the LPP seems to be subject to genetic influence (Weinberg, Venables, Proudfit, & Patrick, 2015), meaning that individual differences in the magnitude of the LPP might serve as a unique, heritable biomarker of an individual's emotional processing (Speed, & Hajcak, 2020).

Previous Emotion Regulation studies that have applied ERP measures have reported a reduction of LPP amplitude across a variety of ER strategies (Ferri & Hajcak, 2015; Hajcak et al., 2010; Hajcak et al.2012; Hajcak, Dunning, Foti, & Weinberg, 2014; Speed, & Hajcak, 2020; Hajcak, & Foti, 2020; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). For example, Moser et al., (2006) recorded an LPP reduction in subjects explicitly instructed to regulate their emotional response, irrespective of strategy applied. In a similar vein, a series of studies found a reduction in LPP, when subjects were implementing reappraisal (Hajcak and Nieuwenhuis, 2006; Foti & Hajcak, 2008; MacNamara, Foti, and Hajcak, 2009; Krompinger, Moser, & Simons, 2008; MacNamara, Ochsner & Hajcak, 2011; Gan, Yang, Chen, & Yang, 2015; Parvaz, MacNamara, Goldstein, and Hajcak, 2012), attentional deployment (e.g. Dunning & Hajcak, 2009; Hajcak, Dunning & Foti, 2009), or suppression (e.g. Moser, Hajcak, Bukay & Simons, 2006).

Overall, changes in the amplitude of the LPP have been found to constitute a reliable measure of both Explicit (e.g. Speed, & Hajcak, 2020; Hajcak, & Foti, 2020; Hajcak, Weinberg, MacNamara, & Foti, 2012; Hajcak, MacNamara, & Olvet, 2010) and Implicit (e.g. Mocaiber et al., 2010; Chen, Yu, Yang, & Yuan, 2020) Emotion Regulation.

In addition, aberrations in the LPP of clinical samples exhibiting emotion regulation deficits , including depression (e.g. Proudfit, Bress, Foti, Kujawa, & Klein, 2015) and the anxiety disorders (e.g. MacNamara & Hajcak, 2010; Paul, Simon, Endrass, & Kathmann,2016) , have led researchers to suggest that the LPP may serve as a neural marker of detecting people at risk for emotion and ER disruptions (Moran, Jendrusinab, & Mosera, 2013; Hajcak et al., 2012; Hajcak, Dunning, Foti, & Weinberg, 2013; Speed, & Hajcak, 2020; Hajcak, & Foti, 2020).

Methodology

Electroencephalographic Recording and Data Processing

The continuous EEG was recorded using a Biosemi Active Two recording system (Biosemi B.V., Amsterdam, the Netherlands). Recordings were taken from 64 scalp electrodes, mounted in an elastic cap using a subset of the International 10/20 System sites (A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A25, A26, A27, A28, A29, A30, A31, A32, B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14, B15, B16, B17, B18, B19, B20, B21, B22, B23, B24, B25, B26, B27, B28, B29, B30, B31 and B30). The ground electrode during acquisition was formed by the Common Mode Sense (CMS) active electrode and the Driven Right Leg (DRL) passive electrode.

The electrooculogram (EOG) generated from blinks and eye movements was recorded from 2 electrodes placed lateral to the external canthus of each eye (approximate distance: 1 cm). In addition, 2 active electrodes were placed on subjects' left and right mastoids, while an additional three were placed on their right (1 active electrode) and left (2 active electrodes) forearms (this was in order to obtain Heart Rate measurements, for further psychophysiological analysis, in a future stage). The EEG and EOG were low-pass filtered using a fifth order sinc filter with a half-power cutoff at 204.8 Hz and digitized at 1024 Hz, with 24 bits of resolution. The single-ended EEG signals were converted to differential signals offline, referenced to the average of the two mastoids (M1, M2).

Signal processing and analysis was performed in Matlab, using EEGLAB toolbox (Delorme and Makeig, 2004) and ERPLAB toolbox (Lopez-Calderon and Luck, 2014). Data was band-pass filtered with cut-offs of 0.1 and 20 Hz. Single-trial EEG epochs were then extracted for a period beginning 200ms prior to image onset and continuing for the entire duration of the image presentation (5000 ms) for the Explicit Emotion Regulation Task (Truchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), while they were extracted for a period beginning 200ms prior to image onset and continuing for the entire duration of image presentation (1000ms) for the Implicit Emotion Regulation Task (Emotional Conflict Adaptation Task, Egner, Etkin, Gale & Hirsch, 2008). Segments of data containing excessive physiological artifact (i.e. voltages exceeding 100 uV) were discarded from further processing. Baseline correction was performed using the 200 ms prior to the onset of the images.

Sample

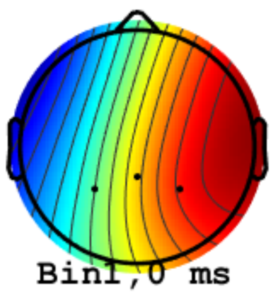
Again the entire research's sample (N=120) was employed for Study 2 and Study 3.

Study 2: The Relationship between Explicit Emotion Regulation Strategies, as measured by the Emotion Regulation Task and Executive Functions: An ERP Study

The Purpose of Study 2 was to obtain electrophysiological measures of each Explicit Emotion Regulation Strategy studied and assess its relationship with behavioural measures of Executive Functions, Implicit Emotion Regulation, as well as psychometric measures of psychopathology (namely, SCL-90-R and PDSQ).

Based on previous research documenting that the LPP is typically maximal at central-parietal sites (Hajcak and Foti, 2020; Speed & Hajcak, 2020; Hajcak et al, 2012; Hajcak et al, 2010), and in accordance to the protocol of the original study from which the specified task was taken (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011), the LPP component was extracted by computing the average signal amplitude collapsed across three sensors, within the central–parietal region (A19/CPz, A32/CP1 and B24/CP2ss) (see **Figure 5** for the scalp locations of the specified electrodes)

Figure 5: Location of electrodes from which the LPP Component was computed

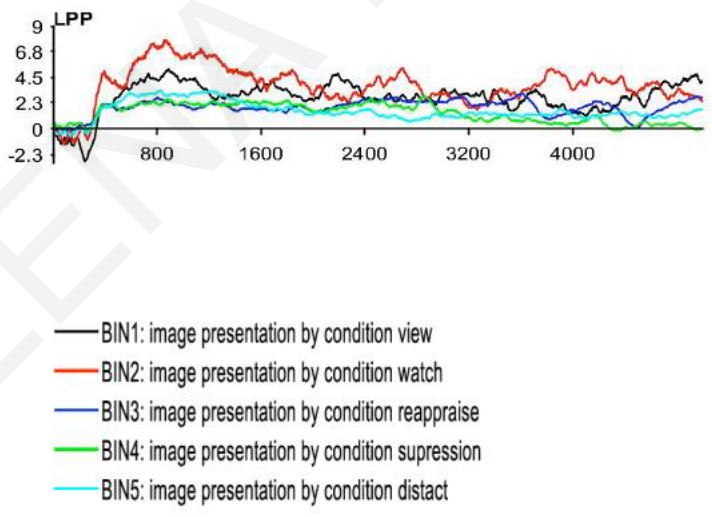


Results for Emotion Regulation Task

In order to ensure that the overall LPP amplitude differed among conditions, a Repeated Measures ANOVA was conducted, were Instruction type (five levels: view-watch-reappraise-suppress-distract) constituted the independent, within-subjects factor, and mean LPP amplitudes for the entire image duration (300–5000 ms) constituted the dependent variable.

Results revealed a main effect of Instruction $F(3.29, 302.33)=2.927$, $p<0.05$.Mauchly's test indicated that the assumption of sphericity had been violated, $\chi2(9) = 56.28$, $p <0.5$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .82$) [Please see **Table 7** for Mean Differences among Conditions for the entire image presentation duration, Appendix]. Also see ***Figure 6*** below for the brain waves of the LPP Component, which was estimated by computing the average of electrodesA19, A32, B24, for each condition, for the entire image duration.

Figure 6: Brain waves for the LPP component for entire image duration, across the entire sample.



In order to test the temporal points at which each regulation strategy modulated the LPP, and in accordance to the protocol of the original researchers and guidelines from previous research which have pursued a time-course analyses of the LPP (Foti and Hajcak, 2008; Thiruchselvam et al, 2011), the first 1400ms of the early stages of the LPP (300–1700 ms) were divided into seven equal 200ms time segments (300–500, 500–700, 700–900, 900–1100, 1100–1300, 1300–1500, and 1500–1700 ms). A Repeated-Measures ANOVA 5

(Instruction Type) X 7 (Time Segment) was performed, which confirmed a main effect of Instruction Type, [$F(2.94, 223) = 6.77$, $p < .001$], as well as a main effect of Time Segment, [$F(2.26 ,172) = 7.9$, $p < .001$). Surprisingly, the interaction between Instruction and Time segment, contrary to previous research (eg. Thiruchselvam et al, 2011), was not significant $F(5.68, 432) = .820$, $p>0.05$. Again, Mauchly's test indicated that the assumption of sphericity had been violated, ($\chi2(9) = 46.25$, $p <0.001$ for time, and $\chi2(20) = 495$, $p <0.001$ for instruction) and $\chi2(299) = 2035$, $p <0.001$ for time*instruction. Thus, degrees of freedom were corrected, this time, using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .73$ for time , $\varepsilon = .38$ for instruction and $\varepsilon = .24$ for time*instruction).

Interestingly, when average Working Memory Ability, Implicit Emotion Regulation and Psychopathology were added to the analysis as covariates, results indicated a significant interaction between Time and Working Memory capacity, for specific time points in the LPP amplitude's trajectory (namely, at time point 4 versus 7, [$F=5.07$, $p<0.05$] and time point 6 versus 7 [$F=4,33$, $p<0.05$]. In addition, the Interaction between Instruction, Time and Psychopathology, was significant for time point 1 versus 7 [$F=4,69$, $p<0.01$], for Reappraisal compared to Distraction. When Inhibition and Shifting were added as covariates, results indicated a main interaction of Time and Inhibition [$F=4.3$, $p<0.01$], with the interaction of Working Memory and Time remaining significant for time points 2 versus 7 [$F=4.55$, $p<0.01$], 3 versus 7 [$F=6.55$, $p<0.01$], 4 versus 7 [$F=7.82$, $p<0.01$] and marginally significant for time point 5 versus 7 [$F=3.66$, $p=0.6$]. No significant effects of interactions were noted for the executive function of shifting.

In order to further delineate the LPP mechanisms for each regulation strategy, as well as explore potential interactions with Updating ability, Implicit ER Ability and Psychopathology, a separate Repeated Measures ANOVA was performed for each Explicit ER Strategy (Reappraisal, Suppression and Distraction), independently.

Results revealed:

- A marginally significant interaction between the ER strategy of Reappraisal and Working Memory ability, for certain stages in the LPP amplitude modulation trajectory (namely, time point 2 versus time point 7 [$F=3.06$, $p=0.8$], time point 3 versus time point 7 [$F=3.3$,$p=0.7$], time point 4 versus time point 7 [$F=3.08$, $p=0.54$] and time point 5 versus time point 7 [$F=3.3$, $p= 0.7$]. When inhibition and shifting were added as covariates, the interaction between Working Memory and Reappraisal became significant for time points 3 versus 7 [$F= 4.4$, $p<0.01$ and 4 versus 7 [$F=5.01$, p<0.01] and marginally significant for time points 5 versus 7 [F=3.7, p=0.58]. No significant effects and/or interactions with Inhibition and shifting were found.

- A statistically significant interaction between the ER strategy of Suppression and Working Memory ability [F(2.01, 189,3]=2.01, p<0.01] was found. Degrees of freedom were, again, corrected, using Greenhouse-Geisser estimates of sphericity [$\chi 2(20) = 526$, p <0.001, ε= .34]. In addition, a statistical significant interaction was found between Suppression and Implicit ER, for time point 4 versus time point 7 [F=5.45,p<0.01] , time point 5 versus time point 7 [F=8.81, p<0.01] and time point 6 versus time point 7 [F=4.45, p<0.01]. A marginally significant effect was also found between suppression and psychopathology, for time point 1 versus time point seven [F=3.1, p=0.8]. When Inhibition was added as a covariate, a significant interaction with suppression and inhibition was also found [F=5.03, p<0.01]
- No significant interaction with psychopathology, implicit ER, Working Memory ability, Inhibition, or Shifting were noted for the ER Strategy of Distraction.

Summary of Results - Brief Discussion for Study 2:

Among the Executive Functions examined, Working Memory Ability and Inhibition were the ones which exhibited a significant interaction with certain Emotion Regulation strategies (significant interaction of Inhibition and Updating with Suppression, and marginal interaction of Updating with Reappraisal), as measured by electrophysiological measures. Significant interactions were also noted between Updating and Inhibition and the temporal dynamics (Time) of the implementation of the abovementioned ER strategies. The Interaction found between Psychopathology, Time and Instruction for specific ER Strategies (Reappraisal vs. Distraction) and time point (3 versus 5), is in line with previous research that supports that Reappraisal and Distraction intervene at distinct stages during the Emotion Generation trajectory (Thiruchselvam et al, 2011), with Distraction intervening earlier than Reappraisal (ibid), and documents individual differences in emotional processing and regulation, in the context of psychopathology (Speed & Hajcak, 2020; Hajcak & Foti, 2020). Interestingly, the strategy for which the greatest effect of Working Memory and Inhibition was found was Suppression. This is in line with previous research documenting an association between habitual suppression, which is regarded in itself as a type of affective inhibition, and updating capacity (Schweizer, Gotlib, & Blakemore, 2020). Suppression was also the only strategy for which a significant interaction with Implicit ER and Psychopathology were found. This is in convergence with existing research that links Suppression to more negative mental health outcomes, compared to other strategies, such as reappraisal (Gross & John, 2003; Aldao, Nolen-Hoeksema, & Schweizer, 2010). In addition, Implicit ER's effect on suppression, could be explained due to a potentially common affective control network implicated in both tasks (Emotional conflict adaptation, where participants need to exert control over an automatic process, namely reading, in the presence of affective stimuli, and the act of inhibiting the emotional response after being exposed to negative affective images, in the case of suppression) (for instance, see Bartholomew, Heller, & Miller, 2021).

Lastly, the absence of any interactions with the Strategy of Distraction, might point to the implication of distinct/alternate cognitive process e.g. attention, which also would need to be controlled for.

Study 3: The Relationship between Implicit Emotion Regulation, as measured by the Emotional Conflict Adaptation Task (Egner, Etkin, Gale & Hirsch, 2008) and Executive Functions: An ERP Study

The Purpose of Study 3 was to obtain electrophysiological measures of Implicit Emotion Regulation, as measured by the Emotional Conflict Adaptation Task (Egner, Etkin, Gale & Hirsch, 2008) and assess its relationship with behavioural measures of Executive Functions, as well as psychometric measures of psychopathology (namely, SCL-90-R and PDSQ).

For this purpose, again changes in LPP Amplitude were utilized as a direct index of Implicit Emotion Regulation.

Again, the LPP component was extracted by computing the average signal amplitude collapsed across three central–parietal sites (CPz, CP1 and CP2). Implicit Emotion Regulation was measured behaviourally as the difference in Reaction Times between Incongruent Trials preceded by a Congruent trial and those occurring after a congruent trial. Electrophysiological Implicit ER measures were extracted by contrasting LPP amplitudes among both abovementioned conditions.

Results for Emotional Stroop Task

Behavioural Analysis

A 2 (congruent trials vs incongruent trials) x 2 (following a congruent or following an incongruent trial) Repeated Measures ANOVA was conducted on participants' Reaction Times, with results revealing a Main Effect of Congruency, $F= 8.41$, $p<0.05$. In order to assess whether there were any significant differences between Reactions Times for

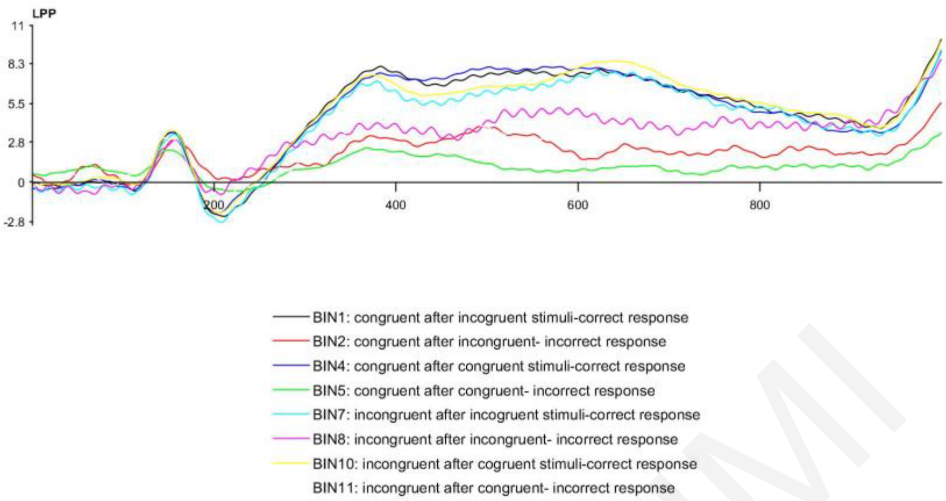
Incongruent Trials that had occurred after an in incongruent trial (high conflict resolution) and incongruent trials that had occurred after an incongruent trial, results were followed-up with a paired sample T-test, which confirmed a significant difference, among the two abovementioned conditions [$t(115)= -2.403$, $p<0.05$, $d=.64.4$]. [Mean for Incongruent Trials that had occurred after an in incongruent trials. $M=499,20$, $SD=67.66$; Mean Incongruent Trials that had occurred after a congruent trial = 513.57, $SD=68.04$].

A Multiple Analysis of Variance (MANOVA) was subsequently performed on the behavioural data with Reaction times (Incongruent trials that had occurred after an in incongruent trial and incongruent trials that had occurred after an incongruent trial) constituting the dependent variable, in order to examine potential Main Effects of Psychopathology, with regard to observed differences in both conditions. A main effect was indeed found for Psychopathology [$F=3,13$, $p<0.05$]. When Working Memory ability was entered as a covariate, Psychopathology's main effect remained significant [$F=3.12$, $p<0.01$], but no significant covariance was found with working memory ability. The main effect of psychopathology became marginally significant, when inhibition was entered as a covariate, while no effects and/or interactions with inhibition were found.

Analysis of Electrophysiological Data

A Multiple Analysis of Variance (MANOVA) on the full duration of the electrophysiological data proved a Main Effect of Psychopathology, on participant's correct responses, among both conditions (incongruent trials preceded by an incongruent trial [$F=4.67p<0.05$] and incongruent trials preceded by a congruent trial [$F=1.001$, $p<0.05$]). When inhibition was added as a covariate, a main effect of inhibition on accurate responses in incongruent trials that had occurred after an incongruent trial was found [$F=5.9$, $p<0.05$]. Please **see Figure 7** for the Brain Waves of the LPP component, as estimated by computing he averages of electrodes A19, A32 and B24, for the entire stimuli presentation duration, for each condition (congruent, incongruent followed by congruent or incongruent trail) and each type of response (correct, incorrect or no response).

Figure 7: Brain waves for the LPP component for entire stimulus presentation, for each condition and type of response, across the entire sample.



To test the different points at which the LPP was modulated, and to test whether a modulation could be observed earlier than the 300ms time window (given implicit processes), we divided the timeframe of recorded signal into 4 equal segments. Again, each segment had a duration of 200ms each, in order to converge with the epoching done for the Explicit ER task (namely, 100-300ms, 300-500ms, 500-700ms and 700-900ms).

A Repeated-Measures ANOVA 2 (Condition) x 4 (Time Segment) was conducted for each type of response (correct, incorrect, no answer), with Updating Ability and Inhibition ability, as covariates.

Results Indicated:

1.For correct responses, a main Effect of Time [$F=81.14$, $p<0.05$] and a marginal interaction between Time and Updating for Time Point 3 vs 4 [$F=3.43$, $p=0.067$]. No other significant result was reported, nor any interactions with inhibition were noted, when the latter was added in the analysis as a covariate.

2.For incorrect responses, a significant interaction was recorded between Time and Updating, F=3,720, $P<0.05$, and for Time and Inhibition, $F=4.15$, $p<0.05$. Comparisons between each time point, revealed a significant interaction for time and Inhibition at time points 1 vs 4 $F=5.75$, $p<0.05$ and 2 vs 4, $F=4.58$, $p<0.05$.

3.No significant effects were reported for conditions where no answer was given.

Summary of Results - Brief Discussion for Study 3:

In line with previous research, results point towards differential implicit emotion regulation processes in psychopathology (Etkin et al., 2010; Etkin, & Schatzberg, 2011). Updating's and Inhibition's significant interaction with the temporal dynamics of the electrophysiological responses (especially, incorrect compared to correct responses), as well as Inhibition's main effect on incorrect responses, provide evidence towards the implication of both EF constructs in Implicit Emotion Regulation (e.g. Sperduti et al., 2017 for Implicit ER's association to Updating; Bartholomew, Heller, & Miller, 2021 and Schweizer, Gotlib, & Blakemore, 2020, for the relation between inhibitory control and emotion inhibition) , on a neural level.

General Discussion – Combining Results from Study 2 and 3

Analysis of Electrophysiological data, both for the Explicit Emotion Regulation implemented in the current study (adapted from Thiruchselvam et al, 2011) and the Implicit Emotion Regulation Task (Egner, Etkin, Gale & Hirsch, 2008), combined with behavioural data obtained for the EF constructs outlined in Miyake et al., (2000), and Friedman & Miyake, (2017), as well as psychometric measures of psychopathology (SCL-90-R and PDSQ), overall, indicated a significant interaction of Updating and Inhibition with electrophysiological measures of both Explicit and Implicit ER ability (namely, changes in LPP amplitude). In addition, aberrations in the ER implementation trajectory were found for participants presenting with affective disorder symptoms for certain Explicit ER strategies (Distraction vs. Reappraisal), as well as for Implicit ER's electrophysiological data.

Current results are in convergence with the behavioural data obtained and analysed in Study 1, which also point towards a relationship between ER, Updating and Inhibition. Again, it is worth recalling Friedman &Miyake's (2017) revised theoretical model, which delineates Inhibition as a hierarchically subordinate EF factor, to Shifting and Updating. Thus, it is difficult to extract inferences for the separate contribution of each EF to both Explicit and Implicit ER ability. A future direction of the current research is the analysis of electrophysiological data that have also been obtain for Inhibition and Updating, while participants were completing the corresponding EF tasks in the laboratory. Specifically, a frequency analysis of the EEG data that has been obtained by the WM task employed in the current research (Letter memory, Morris & Jones,1990) will be conducted, and an effort will be made to combine data from the specified task with the EEG data obtained by the study's Explicit and Implicit's Emotion Regulation task, in order to make inferences about their correlations on a neural and network-level, with regard to brain functionality. A similar analysis could be pursued for the study's Inhibition task, for which EEG and ERP data have also been obtained (Antissaccade, Hallett, 1978).

Finally, in line with results obtained from Study 1, a significant effect and or/interaction of ER measures (both implicit and explicit) with psychopathology on a neural level was found, again pointing towards ER's central role in psychopathology (Jazaieri, Urry, & Gross, 2013).

Future Directions – Implementations

Research and Methodological Implications

1.*Combining electrophysiological data with EF tasks and among implicit and Explicit ER tasks and following Confirmatory Factor Analysis with Network analysis*

As already mentioned, electrophysiological measures of the study's Working Memory and Inhibition task will also be analysed and combined with the EEG/ERP data of the Study's Explicit and Implicit ER's task, via a Frequency Analysis, in order to make inferences about heir association on a neural and, ultimately, network level, with regard to brain functionality, as such inferences cannot be made via the current ERP analysis conducted, which mostly provides information about temporal trajectories. A similar attempt for inferring neural associations will be worth making, by combining the EEG Data obtained by the Explicit and Implicit task. At current, previous research on the relationship between Explicit and Implicit ER supports the existence of a dual process (e.g. Hopp et al., 2011), even though a lack of a unified computational and mechanistic framework of the two processes still exists (Etkin, Büchel, & Gross, 2015). Even though explicit and implicit ER may partially recruit common neurocognitive pathways and seem to operate complimentary (e.g. Hopp et al., 2011; Bartholomew, Heller, & Miller, 2021), with a dynamic interplay reported between both processes (Koole, Webb, & Sheeran, 2015), as previously noted, important differences are observed between the circuitry of both types of ER, which are worth further delineating.

What is more, given an even larger sample size, the findings of Study 1 of the current thesis, could be potentially extended via the conduction of a Network analysis which will aid in further delineating the complex inter-relations among the core constructs under study [Executive Functions, Emotion Regulation (Implicit, Explicit), Psychopathology], where both behavioural and electrophysiological data, could be combined.

2. Combining electrophysiological, behavioural, psychometric and psychophysiological data

In relation to the above and again, in accordance to proposed RdoC methodology, which supports the integration of several units/measures of analysis of the construct under study, EEG/ERP and behavioural data of the current study, could be further combined with psychophysiolocical data, in order obtain a more comprehensive understanding of the complex interplay of EF and ER Processes. This is even more important, given the complex and questionable coherence among the subjective, physiological and behavioural components of the emotional response (Mauss et al, 2005) itself.

3. Connections with RDoC Framework

The current thesis has implemented an RDoC research framework, according to which the sample was taken by the community with no exclusion criteria, from varying affective disorders, in order to assess the whole range of functioning of the constructs under study, from normal to abnormal, while several measures (units of analysis) (i.e. behavioural, electrophysiological, psychometric) of the specified constructs were obtained. Indeed, and in accordance with the goals of the RDoc Framework, which aims to identify potential perturbations in neural circuits that may span across multiple disorders and underly behavioural manifestations of clinical symptomology, the current thesis has contributed to informing this framework by identifying common mechanisms and functions transdiagnostically across disorders, which in turn will constitute targets of intervention and prevention, as well as assessment and, accordingly, inform future nosological manuals (Cuthbert, & Morris, 2021): Namely, perturbations in Executive Functions, Emotion Regulation Ability (both explicit and implicit) as being central transdiagnostically to Clinical Symptomatology, and thus should constitute direct targets of assessment and intervention (see following section, clinical implications. In addition, more information about these disruptions on a circuitry level are expected to occur, following the conduction of the planned frequency analysis of obtained electrophysiological data for EF and implicit and explicit ER task, and their interconnetions).

An additional contribution of the current research was implementing several units of analysis (paradigms, self-report measures, electrophysiological and behavioural) for the construct of Emotion Regulation and thus adding to their establishment and standardization as valid measures of the domain of ER, as well as demonstrating the adding value of incorporating neuroscientific measures. Currently the construct of Emotion Regulation, even though widely acknowledged as a Transdiagnostic Factor, is not included in the RDoC Matrix, as a distinct domain (Fernandez et al., 2016). The current thesis aligns with the view of other researchers and experts in the field of Emotion Regulation (e.g. Fernandez, Jazaieri & Gross, 2016; Sun et al., 2017), which favour the inclusion of Emotion Regulation as a separate domain in the RDoC matrix, and demonstrated how the specific construct is functionally connected and interacts with all other six existing and more molecular RDoC domains (Negative Valence Systems, Positive Valence Systems, Cognitive systems, Systems for Social Processes, Arousal and Regulatory Systems and Sensorimotor Systems (Fernandez et al., 2016).

Overall, according to proposed guidelines the current thesis implemented an integrative study design which included multiple diagnostic groups, units of analysis and granularity levels (e.g. Cognitive Control at a higher functional level, as well as the underlying operations of Working Memory and Inhibition, which are included in the Current RDoC matrix, separately).

In addition, it endeavoured to capture various aspects of emotion regulation , assessed symptoms dimensionally, alongside with related transdiagnostic factors (namely, Executive Functions and Psychopathology, as well as physical health via the implementation of SCL-90- R), in order to obtain a better understanding of how emotion regulation is effected by and effects other factors (Fernandex et al, 2016). What is more, it also showed how “blurring of boundaries “ (Sun et al, 2017) do not only exist between diagnostic categories, but also potentially within traditional psychological concepts, such as cognition and emotion (ibid).

Clinical Implications

Several important implications can be derived from the current study, as its results outline the mechanisms that can be targeted for treatment, in a range of disorders, with common underlying deficits in the domains of Emotion Regulation and Executive Functions.

Initially, the relationship found, in the present study, between Emotion Regulation and the affective disorders investigated, documents the focal role of the former in their clinical presentation. Therefore, the goal of strengthening Emotion Regulation ability holds a specialclinical value, transdiagnostically, across all the affective disorders.

On the other hand, the relationship found between Executive Functions (and more specifically, Working Memory and Inhibition) and Emotion Regulation, provides data in favour of the effectiveness of interventions aiming to enhance this executive function, with the ultimate goal of targeting deficits in Emotion Regulation, and consequently, clinical symptomatology (Schweizer et al., 2011; 2013). In the same way, data are provided in favour of the integration of more recent neuroscientific methods (tDCS) for the activation of the common brain structures implicated in the two abovementioned constructs (Working Memory and Emotion Regulation), in the treatment of all the affective disorders, irrespectively (e.g. Vanderhasselt et al., 2013).

Finally, the relationship found between clinical symptomatology and Implicit Emotion Regulation provides data in favour of its central role in the manifestation of Psychopathology, as well as the potential effectiveness of implementing interventions explicitly targeting Implicit Emotion Regulation's brain circuitry. More specifically, to my knowledge, no interventions aiming to augment Implicit Emotion Regulation ability have been implemented until now.Their development and inclusion, therefore, in current clinical practice, yields great prospects.

Current Progress/Status: Current thesis's studies that are still pending/ still under investigation

Implementing Computerized Brain-Trainings aiming to augment ER ability

Given (a) the current study's findings concerning the relationship between EF and ER ability and (b) the relationship found between either behavioural or electrophysiological ER measures (both explicit and implicit) and psychopathology and (c) in an effort to comply with recent advancements in clinical treatment, aiming to develop neurobehavioural interventions that target the neurobiological mechanisms and the specific biological and neural circuitry deficits thought to underlie psychological disorders, the specific research aims to implement current findings by further investigating the effectiveness of three computerized trainings, aiming to target both explicit and implicit ER's brain circuitry. Namely, the results of the present study have been utilized and served as a basis for the design and current implementation on a pilot level of the following three trainings, to three separate training groups:

Training 1 – eWM Training (Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013):

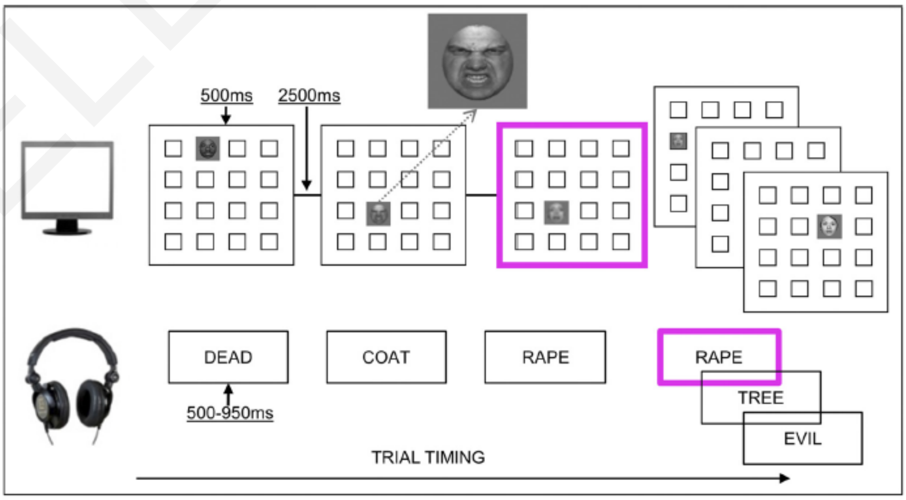
Given successful ER's link to WM Updating ability and previous research indicating that WM training leads to more effective ER (for a recent metanalysis see Barkus, 2020), the current research will aim to investigate the effects of an affective WM training, aimed to target both EF and ER's neural circuitry, and namely a working memory task implemented in an affective context (Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013) in enhancing ER ability, in a community sample (with and without psychopathology).

The current research will employ the emotion WM training protocol designed and implemented by Schweizer, Hampshire, & Dalgeish, (2011), and Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, (2013). The eWM training protocol consists of an affective-dual n-back task where a face is presented for 500ms on a 4x4 grid, while a simultaneously a word is presented via headphones for 500-950ms. **[see illustration of eWM training,** taken by Schweizer, Hampshire, & Dalgeish, below **].** Each picture-word pair is followed by an interval of 2500ms, in which participants respond via pressing a button if either/both stimuli from the pair displayed, is the same as the corresponding face/word presented n positions back; 60% of the words and faces will have a negative emotional valence, while the others will be neutral. The order or trial presentation will be randomized across training sessions.

The training will last for 20 days, where 20 blocks of 20 trials will be presented at each training session (average daily training duration 20 -30 mins).

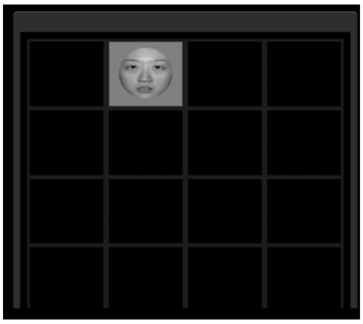
For each block, ten trials will constitute "target trials", where the presenting stimuli will match the stimuli presented n positions back (four visual and four auditory target trials and two presenting both a visual and auditory target).When 3 successive trials are completed correctly, the level of n-back increases by one on the next block. On the contrary, the level of n-back decreases by 1 on the next block, if five or more consecutive trials are completed erroneously. Therefore, maximum performance level for each participant is established.

Illustration of eWM training



[taken by Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013, p.5302].

Screen Shot of Task:



[Taken by Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013]

The emotional words included in this work have been taken and adapted by Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish (2013) (by permission), and have been translated in Greek via the forward - backward method. All words have been standardized (assessed on the domains of valence and arousal) via admission to a sample of students at the University of Cyprus, which is not included in the final sample of the current study (Please find list of words below).

Inquisit software (Millisecond Software, LLC) has been used for the development and implementation of the current training [Please find a list of all the translated Greek auditory stimuli/ words in ***Table***8]

Training 2: Working Memory Training without Emotional Stimuli – Dual N back (Jaggie et al, 2008)

For the purposes of delineating whether WM training without emotional stimuli, is (equally) effective in producing transfer effects to ER ability, or whether emotional stimuli are a significant ingredient of the intervention's effectiveness on ER measures, an n-back training without emotional stimuli will also be applied, to a separate treatment group. Interestingly, affective working memory training but not classical working memory training, has also been found to lead to transfer effects to implicit emotional control, as measured via a modified emotional face-colour Stroop task (Pan, Hoid, Wang, Jia, & Li, 2020).

The training protocol has been taken by Jaggie et al., (2008), and translated to Greek and constitutes a classic n-back task. During the specified task, a blue square (visual stimulus) is presented in one of eight possible locations on the screen for 500 ms, while a consonant (auditory stimulus) is simultaneously played via headphones, followed by a 2500 ms interval. (Please see illustration of Training, taken bt Jaggie et al., 2008, with permissions).

During the between-trials interval, participants are asked to signal through button press if the current trial is a *target trial*, meaning if the current stimulus matches the one presented *n* positions back.

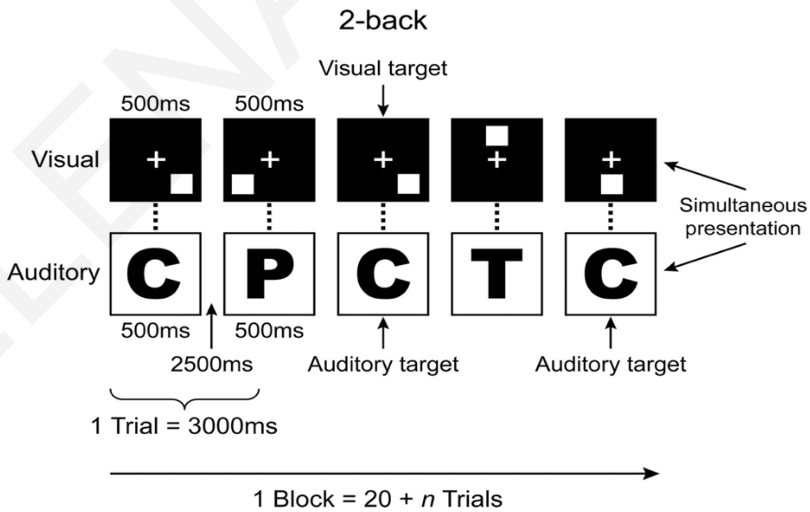
The value of n will differ from one test block to another, while the project will be constantly adjusted in accordance to each participant's performance. As his/her performance improves, n will increase by one value, while as his/her performance deteriorates, n will decrease by one value. This will ensure that the project remains demanding and that maximum performance for each participant is attained.

The duration of this Training will be exactly the same as the eWM Training with emotional stimuli (20 days) and will include 20 blocks, with 20 trials in each training session (average daily training duration 20-30 minutes).

Since the sample of the current study consists of Greek-speaking individuals, eight Greek consonants were selected (μ, ν, ξ, π, ρ, φ, χ, ψ). Measures were taken to ensure equivalence in terms of their memory demands (e.g.one syllabus letters), and establish as much homogeneity as possible, in terms of cognitive load and thus, difficulty between trials.

Again, Inquisit software (Millisecond Software, LLC) has been used for the development and implementation of the current modified (translated to Greek) training

Illustration of N-back task, taken by Jaggie et al., 2008



[Taken by Jaeggi et al, 2008, p. 6830]

Training 3 – Implicit Emotion Regulation task (Affect Labelling, Lieberman, 2007)

Previous Research has suggested that the essence of difficulties in psychopathology, and most commonly in the affective disorders, might lay, mostly, in implicit, rather than explicit forms of ER (e.g. Etkin et al., 2010;2011; Gyurak et al., 2011), while a link between psychopathology and Implicit ER, has also been documented by the electrophysiological data of the current study.

Brain areas implicated in Implicit Emotion Regulation and more specifically, the vmPFC, seem to be common with those implicated in a number of core emotion regulation related functions, such as extinction (Phelps, Delgado, Nearing, & Ledoux, 2004), reversal learning (Schiller & Delgado, 2010) and meditation (Tang et al., 2015). Moreover, vACC (Etkin & Schatzberg, 2011) and vmPFC abnormalities have in particularly, been found to be implicated in psychopathology e.g.(Myers-Schulz & Koenigs, 2014; Roy et al., 2012), while differential connectivity between vmPFC and amygdala during reappraisal, has been reported in psychiatric populations (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007).

Several studies have provided evidence in favour of the efficacy of Implicit forms of ER (e.g. Etkin, 2011; Hallam et al., 2015; Hopp, Troy, & Mauss, 2011; Hou, Yan, Jiang, Wang, & Li, 2016; Jackson et al., 2003; Kobylinska & Karwowska, 2015; Koole & Fockenberg, 2011; Lieberman et al., 2007; Mauss et al., 2007; Tupak et al., 2014; Kircanski et al, 2012; Lieberman et al., 2011; Torre & Lieberman, 2018), and documented how repeated training in explicit ER strategies, might result in increased implicit ER ability (e.g. Christou-Champi, Farrow, & Webb, 2014). Implicit or explicit training of automatic interpretation biases (e.g. Tran, Siemer, & Joormann, 2011), has also led to positive outcomes. However, to my knowledge no study has implemented an implicit ER training, by repeatedly implementing an implicit ER task, nor has a computerised study, thus far, directly attempted to target implicit ER's neural circuitry.

The aim of this training protocol is to measure the effects of a systematic implicit ER training, in enhancing emotion regulation ability in a community population. For this purpose, the current study will implement the Affect Labelling task (i.e. Lieberman et al., 2007; Hariri et al., 2000) described in previous sections in a third training group, as a training task intending to target Implicit ER's brain circuitry.

In a typical affect labelling task (e.g. Lieberman et al., 2007; Hariri et al., 2000), participants are asked to name the emotion expressed by a person, e.g. state whether he is angry or frightened, by matching it with the corresponding word expressing the emotion depicted (please, see illustration below with exemplar stimuli).

In the current training, participants will be presented with 20 blocks of 20 trials each. In 80% of the trials, the target image will express a negative emotion (eg. fear or anger), while in 20% of the trials, the target image will express a positive emotion (e.g. joy or surprise). Half of the trials will entail male faces, while the other half will include female faces.

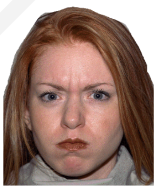
The selection of the two available words/labels for each image will be made in such a way that both words will be in convergence with the valence of the depicted emotion (negative or positive), e.g. two words that convey a negative emotion will be presented as available options for images that express a negative emotion, and respectively, two words that convey a positive emotion, will be offered as available answers for facial images that express a positive emotion.

All facial emotional images have been taken, with permission, by Tottenham, Borscheid, Ellersten, Markus, & Nelson, (2009), who provide a standardised colourful and multiracial set of images with facial expressions. The specific images depict a large number of emotions, with a great variation in the expression of each emotion offered (Nim Sim set of facial expressions; available for research purposes and upon request at the link: http://www.macbrain.org/resources.htm).

The specific dataset of facial emotional images has been standardized in both healthy and clinical populations and has proven to exhibit very good levels of validity and reliability. For the purposes of the current training, the images that demonstrated the highest psychometric properties, from the initial pool (Tottenham, Borscheid, Ellersten, Markus, & Nelson, 2009), were carefully selected and then initially administered to a number of students not included in the final study, for standardization purposes.

Limesurvey (LimeSurvey GmbH, Hamburg, Germany) an open-source survey tool, was utilized for the implementation of the current training.

***Illustration* of task:**



| ΘΥΜΟΣ ΦΟΒΟΣ | ΧΑΡΑ ΈΚΠΛΗΞΗ

[taken and adapted by Lieberman et al, 2007].

Current Progress and Results:

All three trainings are currently being piloted and have been administrated to a small number of participants. For pre and post measurements: 1) a very short version of the study's Explicit Emotion Regulation Task has been implemented (a total of 40 images, where participants are asked to simply view/watch on half on the trials and implement any taught regulation strategy -reappraisal, suppression, distraction – they wish, on the other half) 2). A classical forward and backward digit span task (Lumiley & Calhoon, 1934), via Inquisit Software (Millisecond Software, LLC) and 3) the Questionnaires of the current research (PDSQ, SCL-90, ERQ and DERS), via Survey Monkey (SurveyMonkey Inc., San Mateo, California, USA), were administered.

To comply with the current social distancing measures and ensure minimal interaction, the trainings are currently taking place online, while explicit instructions and administration of pre and post-tests have been done, via online video-call sessions.

Upon completion of the piloting phases, all three trainings will be administered to three separated training groups (n=30 for each group), while a control (n=30), and a placebo training (n=30) group, will also be entailed.

Upon data collection, Repeated Measures MANOVA will be utilized for data analysis, and results will be combined from all four training groups, in order to compare optimum treatment effectiveness.

Results from the current piloting phase are expected to provide insights in terms of optimum training days and trials, as well as method of administration (e.g. in the labarotary or online).

Given the results of the current study (i.e. Inhibition's significant interaction with electrophysiological data of ER, and specifically, Implicit ER), future directions might entail the development and implementation of an intervention combining updating and inhibition/affective control training, or even integrate components (also recommended, in an extensive review of ER training by Cohen & Ochsner, 2018), such as components of EF (Updating and Inhibition) and Implicit ER training. In addition, including a group that does not undergo training but is systematically exposed to the affective stimuli used in the eWM training (Schweizer et al., 2011; 2013) or Affect Labelling Training (Lieberman et al, 2007), could further clarify the effect that the nature of the stimuli can have on ER and WM processes (Schweizer et al, 2019).

Furthermore, ERP measures could be obtained pre and post to treatment to further delineate the neural and temporal mechanisms involved in augmenting ER ability, via computerized training (e.g. Xiu, Wu, Chang & Zhou, 2018). In relation to the above and again, in accordance to proposed RdoC methodology, which supports the integration of several units/measures of analysis of the construct under study, EEG/ERP and behavioural data of the current study, could be further combined with psychophysiolocical data, In relation to the above and again, in accordance to proposed RdoC methodology, which supports the integration of several units/measures of analysis of the construct under study, EEG/ERP and behavioural data of the current study, could be further combined with psychophysiolocical data, in order to obtain a more comprehensive assessment of intervention effectiveness and the complex interplay of EF and ER Processes.

Limitations of the Current Study

The current study presents some limitations. First of all, its sample, consisted mostly of University students, of a specific cultural context, while the majority of the participants were females. Therefore, generalization of results to the entire population, cannot be ensured. In addition, the number of the population (N=120), was particularly small for the conduction of a Confirmatory Analysis, especially while entailing so many complex constructs and measures, and hence, a greater sample size, particularly for Study 1 (Confirmatory Factor Analysis), would have yielded more robust results.

Another important limitation of the current research is the fact that participants were not verbally asked to report their thought and/or other control process, while completing the study's Emotion Regulation task. Thus, we cannot ensure their strict adherence to the instructed, each time, strategy, and condition. As already mentioned, the inclusion of physiological measures, would also add to a more comprehensive understanding of participant's affective and regulatory processes and experience.

Finally, the present study was based on the specific Executive Functions delineated by Miyake et al. (2000)'s mode, and the specific regulatory strategies in proposed by o Gross's process model of Emotion Regulation (1998a; 2015a). The adoption of different theoretical models and the inclusion of other functions and / or other strategies in the EF and ER measurements of the current study, might have yielded different results.

Although there were deviations in the behavioural, psychometric, and electrophysiological measures of the current thesis, as already mentioned these could be attributed to the questionable coherence of the emotional response itself (Mauss et al. 2015) and further stresses the necessity of incorporating a variety of measures in future studies.

Summary - Conclusion

Given evidence of (a) transdiagnostic perturbations in Emotion Regulation and Executive Functions, across numerous disorders, and a potential overlap of EF's and ER's, especially, Explicit's ER, underlying brain circuitry (b) current inconsistent findings with regards to the relation between the specified constructs (c) previous research documenting transfer effects of EF training to augmented ER ability, (d) evidence of Implicit ER, potentially, being more frequently implicated in psychopathology, as well as positive mental health effects occurring from its successful implementation, the aim of the current thesis was to investigate the relationship between EF and ER (Explicit and Implicit) and Psychopathology (namely, Affective Disorder Symptoms), via behavioural, psychometric and ERP Measures.

Behavioural Measures were analysed via a Confirmatory Factor Analysis, while changes in LPP amplitude, served as a measure of, both explicit and implicit, ER ability. Consistent with the thesis's hypotheses, a relationship was found between specific measures of ER, ER strategies and Psychopathology, although not always is the expected directions. More specifically, results of the current thesis could be summarized as follows:

- The specified 7-factor model which was confirmed via CFA, found:

  - a significant correlation between psychometric measures of Emotion Regulation and Psychopathology
  - a marginally significant correlation of Updating and overall behavioural measures of Emotion Regulation
  - a negative correlation between Shifting and psychometric measures of the ER strategy of Reappraisal
  - No significant relationships between Implicit ER and all other constructs, were found, though one of the methodological limitations of the current thesis, was the specified factor merely consisted of a single indicator
  - Even though not confirmed via Confirmatory Factor Analysis, preliminary correlational analysis revealed a significant correlation also between Inhibition and behavioural measures of Emotion Regulation

- Analysis of ER's electrophysiolocal data and its relation to behavioural measures of EF and ER and psychometric measures of ER and psychopathology revealed:

- a significant interaction of the Executive Function of Updating and the strategy of Suppression, as well as Implicit ER. Furthermore, Updating exhibited a significant interaction with Time, on overall ER ability, for specific time points in the ER trajectory, and a marginal significant effect on Reappraisal, only for certain time points (this interaction became significant, when inhibition was controlled for)

- a significant interaction between Suppression, Inhibition, Psychopathology and Implicit ER for certain time points of the ER trajectory, were also found

- Further to Updating, a significant interaction of Inhibition with the temporal dynamics of the Implicit ER' electrophysiological data was also found, (especially, for incorrect compared to correct responses), as well as a main effect of Inhibition on overall Implicit ER's erroneous responses

- A main effect of Psychopathology was found on Implicit ER's ERP data

- An Interaction between Time, Instruction and Psychopathology was found for certain instructed Explicit ER strategies (Distraction vs. Reappraisal), and for certain time points

- The ER strategy of Distraction did not seem to exhibit a significant interaction with measured EF constructs.

Both behavioural and electrophysiological analysis point towards the role of Executive Functions (mostly, Updating and Inhibition), in ER ability, and also delineate the potential complex interactions among the cognitive processes themselves, with regard to successful ER implementation, across time. In addition, behavioural, electrophysiological and psychometric measures of ER, demonstrated a relationship and interaction with administered psychometric measures of Psychopathology (PDSQ; SCL-90-R).

Based on these findings, the current thesis concludes with the investigation of the effectiveness of computerized ER trainings that aim to augment EF and Implicit ER's ability (currently, in pilot phase) and offers suggestions for further analysis of the interplay of EF and ER, especially with reference to brain functionality, on a neural and network level.

Works Cited:

Aldao, A., & Nolen-Hoeksema, S. (2010). Specificity of cognitive emotion regulation strategies: A transdiagnostic examination. Behaviour Research and Therapy, 48, 974–983. http://dx.doi.org/10.1016/j.brat.2010.06.002 .2010.06.002

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. Clinical psychology review, 30(2), 217-237.

Aldao, A., Sheppes, G., & Gross, J. J. (2015). Emotion regulation flexibility. Cognitive Therapy and Research, 39(3), 263-278.

Banks, S. J., Eddy, K. T., Angstadt, M., Nathan, P. J., & Phan, L. (2007). Amygdala–frontal connectivity during emotion regulation. Scan , 2, 303– 312.

Bardeen, J. R., Fergus, T. A., and Orcutt, H. K. (2012). An examination of the latent structure of the difficulties in emotion regulation scale. J. Psychopathol. Behav. Assess. 34, 382–392. Doi: 10.1007/s10862-012-9280-y

Barkus, E. (2020). Effects of working memory training on emotion regulation: Transdiagnostic review. *PsyCh journal*, *9*(2), 258-279.

Barrett, L. F. (2017). How emotions are made: The secret life of the brain. Houghton Mifflin Harcourt.

Bartholomew, M. E., Heller, W., & Miller, G. A. (2021). Inhibitory control of emotional processing: Theoretical and empirical considerations. *International Journal of Psychophysiology*, 163,.5-10.

Beauregard, M., Lévesque, J., & Paquette, V. (2004). Neural basis of conscious and voluntary self-regulation of emotion. In M. Beauregard, Consciousness, Emotional Self-Regulation and the Brain (pp. 163-194). Philadelphia: John Benjamins Publishing Company.

Berboth, S. & Morawetz, C. (2021). Amygdala-prefrontal connectivity during emotion regulation: A meta-analysis of psychophysiological interactions. *Neuropsychologia*, *153*, 107767.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. Journal of behavior therapy and experimental psychiatry, 25(1), 49-59.

Braunstein, L. M., Gross, J. J., & Ochsner, K. N. (2017). Explicit and implicit emotion regulation: a multi-level framework. Social cognitive and affective neuroscience, 12(10), 1545-1557.

Braunstein, L. M., & Ochsner, K. N. (2018). Explicit and Implicit Emotion Regulation. Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience, 4, 1-29

Brown, T. A. (2015). Confirmatory factor analysis.(2nd Edition). New York: The Guilford Press.

Bullis, J. R., Boettcher, H., Sauer-Zavala, S., Farchione, T. J., & Barlow, D. H. (2019). What is an emotional disorder? A transdiagnostic mechanistic definition with implications for assessment, treatment, and prevention. *Clinical Psychology: Science and Practice*, *26*(2), e12278.

Calkins, S. D., & Marcovitch, S. (2010). Emotion regulation and executive functioning in early development: Integrated mechanisms of control supporting adaptive functioning. In Child development at the intersection of emotion and cognition. (pp. 37-57). American Psychological Association.

Carver, C. S., Johnson, S. L., & Timpano, K. R. (2017). Toward a functional view of the p factor in psychopathology. Clinical Psychological Science, 5(5), 880-889.

Caspi A, Houts RM, Belsky DW, Goldman-Mellor SJ, Harrington H, et al. (2014). The p factor: one general psychopathology factor in the structure of psychiatric disorders.Clin. Psychol. Sci. 22,119–137.

Caspi, A., & Moffitt, T. E. (2018). All for one and one for all: Mental disorders in one dimension. *American Journal of Psychiatry*, *175*(9), 831-844.

Castellanos-Ryan, N., Brière, F.N., O'Leary-Barrett, M., Banaschewski, T., Bokde, A., Bromberg, U., Büchel, C., Flor, H., Frouin, V., Gallinat, J. and Garavan, H.,(2016). The structure of psychopathology in adolescence and its common personality and cognitive correlates. J. Abnorm. Psychol. 125(8), 1039–52.

Chen, S., Yu, K., Yang, J., & Yuan, J. (2020). Automatic reappraisal based implementation intention produces early and sustainable emotion regulation effects: Event-related potential evidence. *Frontiers in Behavioral Neuroscience*, *14*, 89.

Christou-Champi, S., Farrow, T. F., & Webb, T. L. (2015). Automatic control of negative emotions: Evidence that structured practice increases the efficiency of emotion regulation. Cognition and Emotion, 29(2), 319-331.

Clark, L. A., Cuthbert, B., Lewis-Fernández, R., Narrow, W. E., & Reed, G. M. (2017). Three Approaches to Understanding and Classifying Mental Disorder: ICD-11, DSM-5, and the National Institute of Mental Health's Research Domain Criteria (RdoC). Psychological Science in the Public Interest, 18(2), 72-145.

Cohen, N., & Ochsner, K. N. (2018). From surviving to thriving in the face of threats: the emerging science of emotion regulation training. *Current opinion in behavioral sciences*, *24*, 143-155.

Coifman, K. G., Kane, M. J., Bishop, M., Matt, L. M., Nylocks, K. M., & Aurora, P. (2021). Predicting negative affect variability and spontaneous emotion regulation: Can working memory span tasks estimate emotion regulatory capacity?. *Emotion*, *21*(2), 297.

Cuthbert, B. N. (2014). The RdoC framework: facilitating transition from ICD/DSM to dimensional approaches that integrate neuroscience and psychopathology. World Psychiatry, 13, 28-35.

Cuthbert, B. N. (2015). Research Domain Criteria: toward future psychiatric nosologies. Dialogues in Clinical Neuroscience, 17(1), 89-97.

Cuthbert, B. N. (2016). The NIMH Research Domain Criteria Project: Toward an Integrated Neuroscience of Mental Disorders. In M. State, B. Miller, & T. Lehner, Genomics, Circuits, and Pathways in Clinical Neuropsychiatry (pp. 397 – 410). Cambridge, MA: Academic Press.

Cuthbert, B. N. (2020). The role of RdoC in future classification of mental disorders. Dialogues in Clinical Neuroscience, 22(1), 81-85.

Cuthbert, B. N., & Insel, T. R. (2013a). Toward the future of psychiatric diagnosis: the seven pillars of RdoC. BMC Medicine , 11 (126), 1-8.

Cuthbert, B. N., & Insel, T. R. (2013b). Toward Precision Medicine in Psychiatry: The NIMH Research Domain Criteria Project. In D. S. Charney, P. Sklar, J. D. Buxbaum, & E. J. Nestler, Neurobiology of mental illness (4th Ed.). New York: Oxford University Press.

Cuthbert, B. N., & Kozak, M. J. (2013). Constructing Constructs for Psychopathology: The NIMH Research Domain Criteria. Journal of Abrnormal Psychology, 122(3), 928-937.

Cuthbert, B. N., & Morris, S. E. (2021). Evolving Concepts of the Schizophrenia Spectrum: A Research Domain Criteria Perspective. Frontiers in Psychiatry, 12,170.

Delorme, A., and Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *J. Neurosci. Methods* 134, 9–21. Doi: 10.1016/j.jneumeth.2003.10.009.

Derogatis, L. R. (1994). Symptom Checklist-90-R: Administration, scoring & procedure manual for the revised version of the SCL-90. Minneapolis, MN: National Computer Systems.

Derogatis, L. R. (2000). Symptom Checklist-90-Revised. In *Handbook of psychiatric measures.* APA (pp. 81-84), American Psychiatric Association.

Derogatis, L. R., Lipman, R. S., Covi, L. (1973) SCL-90: an outpatient psychiatric rating scale –preliminary report. *Psychopharmacological Bulletin, 9*, 13–28.

Derogatis, L. R., Rickels, K., & Rock, A. F. (1976). The SCL-90 and the MMPI: A step in the validation of a new self-report scale. *The British Journal of Psychiatry*, *128*(3), 280-289.

Derogatis, L. R., & Unger, R. (2010). Symptom Checklist-90-Revised. . *The Corsini Encyclopedia of Psychology*, 1-2.

Derogatis, L.R. & Savitz, K.L. (1999). The SCL-90-R, Brief Symptom Inventory, and matching clinical ratings scales. In M. E. Maruish (ed.), *The use of psychological testing for treatment planning and outcome assessment* (pp. 679-724). Mahwah, NJ: Erlbaum.

Doré, B. R., Zerubavel, N., & Ochsner, K. N. (2015). Social Cognitive Neuroscience: A Review of Core Systems. In P. R. M. Mikulincer, APA Handbook of Personality and Social Psychology, Vol 1: Attitudes and Social Cognition (pp. 693-720). Washington, DC: American Psychological Association.

Dreisbach, G., & Fröber, K. (2019). On how to be flexible (or not): Modulation of the stability-flexibility balance. Current Directions in Psychological Science, 28, 3–9. http://dx.doi.org/10.1177/0963721418800030

Dunning, J. P., & Hajcak, G. (2009). See no evil: Directing visual attention within unpleasant images modulates the electrocortical response. Psychophysiology, 46, 28–33.

Egner T, Etkin A, Gale S, Hirsch J. (2008) Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. Cerebral cortex, 18(6), pp.1475–1484.

Ekman, P., & Friesen, WV. (1976), *Pictures of Facial Affect.* Palo Alto, CA: Consulting Psychologists.

Elliott, M. L., Romer, A., Knodt, A. R., & Hariri, A. R. (2018). A connectome-wide functional signature of transdiagnostic risk for mental illness. *Biological psychiatry*, *84*(6), 452-459.

Erdfelder, F. F., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

Etkin, A. (2011). Emerging insights on implicit emotion regulation. Neuropsychoanalysis, 13(1), 42–44.

Etkin, A., & Schatzberg, A. F. (2011). Common Abnormalities and Disorder-Specific Compensation During Implicit Regulation of Emotional Processing in Generalized Anxiety and Major Depressive Disorders. American Journal of Psychiatry, 168, 968–978.

Etkin, A., Büchel , C., & Gross, J. J. (2015). The neural bases of emotion regulation. Nature Reviews Neuroscience , 16, 693–700.

Etkin, A., Egner, T., Peraza, D. M., Kandel, E. R., & Hirsch, J. (2006). Resolving Emotional Conflict: A Role for the Rostral Anterior Cingulate Cortex in Modulating Activity in the Amygdala. *Neuron , 51*, 871–882

Etkin, A., Gyurak, A., & O'Hara, R. (2013). A neurobiological approach to the cognitive deficits of psychiatric disorders. Neurobiology of Cognition in Psychiatric Disorders, 15(4), 419–429

Etkin, A., Prater, K. E., Hoeft, F., Schatzberg, A. F., Sciences, B., Road, Q., & Road,Q. (2010). Failure of Anterior Cingulate Activation and Connectivity with the Amygdala During Implicit Regulation of Emotional Processing in Generalized Anxiety Disorder. The American Journal of Psychiatry, 167(5), 545–554. http://doi.org/10.1176/appi.ajp.2009.09070931.

Etkin, A., & Schatzberg, A. F. (2011). Common abnormalities and disorder-specific compensation during implicit regulation of emotional processing in generalized anxiety and major depressive disorders. *American Journal of Psychiatry*, *168*(9), 968-978.

Fernandez, K. C., Jazaieri, H., & Gross, J. J. (2016). Emotion Regulation: A Transdiagnostic Perspective on a New RdoC Domain. Cognitive Therapy and Research, 40, 426–440. http://doi.org/10.1007/s10608-016-9772-2

Ferri, J., & Hajcak, G. (2015). Neural mechanisms associated with reappraisal and attentional deployment. Current Opinion in Psychology, 3, 17–21. http://doi.org/10.1016/j.copsyc.2015.01.010

Foti, D., & Hajcak, G. (2008). Deconstructing reappraisal: Descriptions preceding arousing pictures modulate the subse quent neural response. Journal of Cognitive Neuroscience, 20, 977–988.

Fox, A. S., Lapate, R. C., Shackman, A. J., & Davidson, R. (2018). Series in Affective Science: The Nature of Emotion: Fundamental Questions. 2nd Edition. New York: Oxford University Press.

Friedman, N. P., Miyake, A., Altamirano, L. J., Corley, R. P., Young, S. E., Rhea, S. A., & Hewitt, J. K. (2016). Stability and change in executive function abilities from late adolescence to early adulthood: A longitudinal twin study. *Developmental psychology*, *52*(2), 326.

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex*, *86*, 186-204.

Gan, S., Yang, J., Chen, X., & Yang, Y. (2015). The electrocortical modulation effects of different emotion regulation strategies. Cognitive Neurodynamics, 9, 399–410. http://doi.org/10.1007/s11571-015-9339-z

Geiser, C. (2012). Data analysis with Mplus. New York: Guilford press.

Goldin, P. R., McRae, K., Ramel, W., & Gross, J. J. (2008). The Neural Bases of Emotion Regulation: Reappraisal and Suppression of Negative Emotion. *Biological Psychiatry , 63* (6), 577–586.

Goodkind, M., Eickhoff , S. B., Oathes , D. J., Jiang , Y., Chang , A., Jones-Hagata , Ortega, B.N, Zaiko, V., Roach, E.L., Korgaonkar, M.S., Grieve, S.M., Galatzer-Levy, I., Fox, P.T. and Etkin, A. (2015). Identification of a Common Neurobiological Substrate for Mental Illness. JAMA Psychiatry. , 72(4), 305–315.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. Journal of Psychopathology & Behavioral Assessment, 26(1), 41-54.

Green, M. J., & Malhi, G. S. (2006). Neural mechanisms of the cognitive control of emotion. Acta Neuropsychiatrica, 18(3-4), 144-153.

Gross, J. J. (1998a). The emerging field of emotion regulation: An integrative review. Review of General Psychology , 2, 271– 299.

Gross, J. J. (1998b). Antecedent- and Response-Focused Emotion Regulation: Divergent Consequences for Experience, Expression, and Physiology. *Journal of Personality and Social Psychology , 74* (1), 224-237.

Gross, J.J. (2014). Emotion regulation: Conceptual and empirical foundations. In J.J. Gross (Ed.), Handbook of emotion regulation (2nd ed.) (pp. 3-20). New York, NY: Guilford.

Gross, J. J. (2015a). Emotion Regulation: Current Status and Future Prospects. Psychological Inquiry , 26, 1–26.

Gross, J. J. (2015b). The extended process model of emotion regulation: Elaborations, applications, and future directions. Psychological Inquiry, 26(1), 130-137.

Gross, J. J., & Jazaieri, H. (2014). Emotion, emotion regulation, and psychopathology: An affective science perspective . Clinical Psychological Science , 2, 387–401.

Gross, J. J., & John, O. P. (2003). Individual Differences in Two Emotion Regulation Processes: Implications for Affect, Relationships, and Well-Being . *Journal of Personality and Social Psychology , 85* (2), 348–362.

Gutentag, T., Halperin, E., Porat, R., Bigman, Y. E., & Tamir, M. (2016). Successful emotion regulation requires both conviction and skill: beliefs about the controllability of emotions, reappraisal, and regulation success. Cognition and Emotion, 9931(August), 1–9. http://doi.org/10.1080/02699931.2016.1213704

Gyurak, A., Goodkind, M. S., Madan, A., Kramer, J. H., Miller, B. L., & Levenson, R. W. (2009). Do tests of executive functioning predict ability to down-regulate emotions spontaneously and when instructed to suppress? Cognitive, Affective, & Behavioral Neuroscience, 9(2), 144–152. http://doi.org/10.3758/CABN.9.2.144.Do

Gyurak, A., Goodkind, M. S., Kramer, J. H., Miller, B. L., & Levenson, R. W. (2012). Executive functions and the down-regulation and up-regulation of emotion. Cognition & emotion, 26(1), 103-118

Gyurak, A., Gross, J. J., & Etkin, A. (2011). Explicit and implicit emotion regulation: A dual-process framework. , 25 (3), Cognition and Emotion, 25 (3), 400 – 412.

Hajcak, G., & Foti, D. (2020). Significance?... Significance! Empirical, methodological, and theoretical connections between the late positive potential and P300 as neural responses to stimulus significance: An integrative review. Psychophysiology, e13570.

Hajcak, G., Dunning, J. P., & Foti, D. (2009). Motivated and controlled attention to emotion: time-course of the late positive potential. *Clinical neurophysiology*, *120*(3), 505-510.

Hajcak, G., Dunning, J. P., Foti, D., & Weinberg, A. (2014). Temporal dynamics of emotion regulation. In J. J. Gross (Ed.), Handbook of emotion regulation (2nd ed., pp. 43–57). New York, NY: Guilford.

Hajcak, G., MacNamara, A., & Olvet, D. M. (2010). Event-related potentials, emotion, and emotion regulation: an integrative review. Developmental Neuropsychology, 35(2), 129–155. http://doi.org/10.1080/87565640903526504

Hajcak, G., Weinberg, A., MacNamara, A., & Foti, D. (2012). ERPs and The Study of Emotion. In S. J. Luck, & E. S. Kappenman, The Oxford Handbook of Event-Related Potential Components (pp. 441-472). New York: Oxford University Press. http://doi.org/10.1093/oxfordhb/9780195374148.013.0222

Hajcak, G.,& Nieuwenhuis, S. (2006). Reappraisal modulates the electrocortical response to negative pictures. Cognitive, Affective, and Behavioral Neuroscience, 6, 291–297.

Hallam, G. P., Webb, T. L., Sheeran, P., Miles, E., Wilkinson, I. D., Hunter, M. D., Farrow, T. F. D. (2015). The neural correlates of emotion regulation by implementation intentions. PloS ONE, 10(3), 1–21. http://doi.org/10.1371/journal.pone.0119500

Hallett, P. E. (1978). Primary and secondary saccades to goals defined by instructions. Vision
Research, 18, 1279-1296.

Hallion, L. S., Steinman, S. A., Tolin, D. F., & Diefenbach, G. J. (2018). Psychometric Properties of the Difficulties in Emotion Regulation Scale (DERS) and Its Short Forms in Adults With Emotional Disorders. *Frontiers in Psychology , 9*, 1-12.

Hare, T. A., Tottenham, N., Davidson, M. C., Glover, G. H., & Casey, B. J. (2005). Contributions of amygdala and striatal activity in emotion regulation. *Biological psychiatry*, *57*(6), 624-632.

Hariri, A. R., Ca, S. Y. B., & Mazziotta, J. C. (2000). Modulating emotional responses : effects of a neocortical network on the limbic system, 11(1), 43–48.

Hariri, A. R., Mattay, V. S., Tessitore, A., Fera, F., & Weinberger, D. R. (2003). Neocortical Modulation of the Amygdala Response to Fearful Stimuli. Society of Biological Psychiatry , 53, 494–501.

Hendricks, M. A., & Buchanan, T. W. (2016). Individual differences in cognitive control processes and their relationship to emotion regulation. Cognition & Emotion, 30(5), 912–924. http://doi.org/10.1080/02699931.2015.1032893

Helion, C., Krueger, S. M., & Ochsner, K. N. (2019). Emotion regulation across the life span. *Handbook of clinical neurology*, *163*, 257-280.

Hoemann, K., Fan, M., Engen, H., Chou, C. A., Quigley, K., Gendron, M., & Barrett, L. F. (in press). A network analytic approach to measuring emotional granularity.

Hopp, H., Troy, A. S., & Mauss, I. B. (2011). The unconscious pursuit of emotion regulation: Implications for psychological health. Cognition and Emotion, 25(3), 532–545. http://doi.org/10.1080/02699931.2010.532606.

Hou, L., Yan, X., Jiang, Q., Wang, H., & Li, C. (2016). Influence of Unconscious Emotional Control Goals Priming on Anticipatory Anxiety and Physiological Activity. Health, 8(14), 1589–1602. http://doi.org/10.4236/health.2016.814156

Hoyle, R. H. (Ed.). (2012). Handbook of structural equation 108abelling. New York: Guilford press.

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, Daniel, S., Quinn, K., Wang, P. (2010). Research Domain Criteria (RdoC): Toward a New Classification Framework for Research on Mental Disorders. American Journal of Psychiatry, 167(7), 748–751. http://doi.org/10.1176/appi.ajp.2010.09091379

Inquisit 6. (2021). Retrieved from https://www.millisecond.com.

Ito, T. A., Friedman, N. P., Bartholow, B. D., Correll, J., Loersch, C., Altamirano, L. J., και συν. (2015). Toward a Comprehensive Understanding of Executive Cognitive Function in Implicit Racial Bias. *Journal of Personality and Social Psychology, , 108* (2), 187–218.

Jackson, D. C., Mueller, C. J., Dolski, I., Dalton, K. M., Nitschke, J. B., Urry, H. L., Davidson, R. J. (2003). Now you feel it, now you don't: Front brain electrical 109abelling and individual differences in emotion regulation. Psychological Science, 14(6), 612–617. http://doi.org/10.1046/j.0956-7976.2003.psci_1473.x

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences*, *105*(19), 6829-6833.

Jasielska A, Kaczmarek L, Brońska A, Dominiak M, Niemier K, Patalas D, Sokołowski A, Tomczak M. (2015). The relationship between working memory and emotion regulation strategies. Roczniki Psychologiczne, 18(4), 567-578.

Jazaieri, H., Urry, H. L., & Gross, J. J. (2013). Affective Disturbance and Psychopathology: An Emotion Regulation Perspective. Journal of Experimental Psychopathology, 4(5), 584-599.

Jazaieri, H., Uusberg, H., Uusberg, A., & Gross, J. J. (2020). Cognitive processes and risk for emotion dysregulation. In T. P. Beauchaine, & S. E. Crowell, The Oxford Handbook of Emotion Dysregulation (pp. 127-139). New York: Oxford University Press.

Johnstone, T., van Reekum, C. M., Urry, H. L., Kalin, N. H., & Davidson, R. L. (2007). Failure to Regulate: Counterproductive Recruitment of Top- Down Prefrontal-Subcortical Circuitry in Major Depression. The Journal of Neuroscience , 27 (33), 8877– 8884.

Joormann, J., & Gotlib, I. H. (2010). Emotion regulation in depression: Relation to cognitive inhibition. Cognition and Emotion, 24(2), 281-298.

Joormann, J., & Vanderlind, W. M. (2014). Emotion Regulation in Depression: The Role of Biased Cognition and Reduced Cognitive Control. Clinical Psychological Science , 2 (4), 402– 421.

Kafetsios, K., & Loumakou, M. (2007) A comparative evaluation of the effects of trait emotional intelligence and emotion regulation on affect at work and job satisfaction. International Journal of Work Organisation and Emotion, 2 (1), 71-87.

Keshavan, M. S., Vinogradov, S., Rumsey, J., Sherrill, J., & Wagner, A. (2014). Cognitive Training in Mental Disorders: Update and Future Direction. American Journal of Psychiatry, 171(5), 510–522. http://doi.org/10.1016/j.immuni.2010.12.017.

Kim, H., & Hamann, S. (2007). Neural Correlates of Positive and Negative Emotion Regulation. Journal of Cognitive Neuroscience , 19 (5), 776–798.

Kircanski, K., Lieberman, M. D., & Craske, M. G. (2012). Feelings into words: contributions of language to exposure therapy. *Psychological science*, *23*(10), 1086-1091.

Kobylinska, D., & Karwowska, D. (2015). How automatic activation of emotion regulation influences experiencing negative emotions. Frontiers in Psychology, 6(OCT), 1–4. http://doi.org/10.3389/fpsyg.2015.01628

Kohn, N., Eickhoff, S. B., Scheller, M., Laird, A. R., Fox, P. T., & Habel, U. (2014). Neural network of cognitive emotion regulation — An ALE meta-analysis and MACM analysis. NeuroImage , 87, 345–355.

Koole, S. L., & Fockenberg, D. a. (2011). Implicit emotion regulation under demanding conditions: the moderating role of action versus state orientation. Cognition & Emotion, 25(3), 440–52. http://doi.org/10.1080/02699931.2010.544891

Koole, S. L., Webb, T. L., & Sheeran, P. L. (2015). Implicit emotion regulation: Feeling better without knowing why. Current Opinion in Psychology, 3, 6–10. http://doi.org/10.1016/j.copsyc.2014.12.027

Kozak, M. J., & Cuthbert, B. N. (2016). The NIMH Research Domain Criteria Initiative: Background, Issues, and Pragmatics. Psychophysiology, 53, 286–297. http://doi.org/10.1111/psyp.12518

Kring, A. M., & Mote, J. (2016). Emotion Disturbances as Transdiagnostic Processes in Psychopathology. In L. F. Barrett, M. Lewis, & J. M. Haviland-Jones, Handbook of Emotions (4th Edition) (pp. 653-669). New York: The Guilford Press.

Krompinger, J. W., Moser, J. S., & Simons, R. F. (2008). Modulations of the electrophysiological response to pleasant stimuli by cognitive reappraisal. Emotion, 8, 132–137

Kuppens, P., Tuerlinckx, F., Russell, J. A., & Barrett, L. F. (2013). The relation between valence and arousal in subjective experience. Psychological bulletin, 139(4), 917.

Lahey BB, Applegate B, Hakes JK, Zald DH, Hariri AR, Rathouz PJ. 2012. Is there a general factor of prevalent psychopathology during adulthood? J. Abnorm. Psychol. 121(1), 971–77.

Lang, P. J. (1980). Behavioral treatment and bio-behavioral assessment: Computer applications. In J. B. Sidowski, J. H. Johnson, & T. A. Williams (Eds.), *Technology in mental health care delivery systems* (pp. 119–137).

Lang, P. J. (1994). The motivational organization of emotion: Affect–reflex connections. In S. H. M. van Goozen & N. E. Van de Poll (Eds.), Emotions: Essays on emotion theory (pp. 61–93). Hillsdale, NJ: Erlbaum

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2005). International affective picture system (IAPS):Affective ratings of pictures and instruction manual. Technical Report A-6. University of Florida, Gainesville, FL.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8. University of Florida, Gainesville, FL.

Lee, D. J., Witte, T. K., Weathers, F. W., & Davis, M. T. (2015). Emotion regulation strategy use and posttraumatic stress disorder: Associations between multiple strategies and specific symptom clusters. Journal of Psychopathology and Behavioral Assessment, 37, 533–544. http://dx.doi.org/10.1007/s10862-014-9477-3

Lee, T. W., & Xue, S. W. (2018). Does emotion regulation engage the same neural circuit as working memory? A meta-analytical comparison between cognitive reappraisal of negative emotion and 2-back working memory task. PloS one, 13(9), e0203753.

Liang, Y., Huo, M., Kennison, R., & Zhou, R. (2017). The role of cognitive control in older adult cognitive reappraisal: Detached and positive reappraisal. Frontiers in Behavioral Neuroscience, 11, 27.

Lieberman, M. D., Eisenberger, N. I., Crockett, M. J., Tom, S. M., Pfeifer, J. H., & Way, B. M. (2007). Putting feelings into words: Affect 111abelling disrupts amygdala activity in response to affective stimuli. Psychological Science, 18(5), 421–428. http://doi.org/10.1111/j.1467-9280.2007.01916.x

Lieberman, M. D., Inagaki, T. K., Tabibnia, G., & Crockett, M. J. (2011). Subjective responses to emotional stimuli during 111abelling, reappraisal, and distraction. *Emotion*, *11*(3), 468.

Limesurvey GmbH. / LimeSurvey: An Open Source survey tool. Hamburg, Germany. URL http://www.limesurvey.org

Lopez-Calderon, J., & Luck, S. J. (2014). ERPLAB: An open-source toolbox for the analysis of event-related potentials. Frontiers in human neuroscience, 8, 213.

Luck, S. J. (2005). An introduction to the event-related potential technique. Cambridge, MA: The MIT Press.

Lumiley, F. H., and Calhoon, S. W.(1934). Memory Span for Words Presented Auditorially. *Applied Psychology,* 18, 773-784.

MacNamara, A., & Hajcak, G. (2010). Distinct electrocortical and behavioral evidence for increased attention to threat in generalized anxiety disorder. Depression and Anxiety, 27, 234–243.

MacNamara, A., Foti, D., & Hajcak, G. (2009). Tell me about it: neural activity elicited by emotional pictures and preceding descriptions. *Emotion*, *9*(4), 531.

MacNamara, A., Ochsner, K., & Hajcak, G. (2011). Previously reappraised: The lasting effect of description type on picture- elicited electro cortical activity. Social Cognitive and Affective Neuroscience, 6(3),348-358

Mauss I. B., & Tamir, M. (2014). Emotion goals: How their content, structure, and operation shape emotion regulation. In J. J. Gross (Ed.), The Handbook of Emotion Regulation, 2nd Ed (pp. 361-375). New York, NY: Guilford Press.

Mauss, I. B., Cook, C. L., & Gross, J. J. (2007). Automatic emotion regulation during anger provocation. Journal of Experimental Social Psychology, 43, 698–711. http://doi.org/10.1016/j.jesp.2006.07.003

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior and physiology. Emotion , 5, 175-190.

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314-324.

Mayr, U., & Kliegl, R. (2000). Task-set switching and long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26, 1124–1140.*

McRae, K., & Gross, J. J. (2020). Emotion regulation. Emotion, 20(1), 1-9. http://dx.doi.org/10.1037/emo0000703

McRae, K., Jacobs, S. E., Ray, R. D., John, O. P., & Gross, J. J. (2012). Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. Journal of Research in Personality, 46(1), 2-7.

McRae, K., & Zarolia, P. (2020). Cognition and Emotion in Emotion Dysregulation. In T. P. Beauchaine, & S. P. Crowell, *The Oxford Handbook of Emotion Dysregulation* (pp. 39-52). USA: Oxford University Press.

McTeague, L. M., Goodkind, M. S., & Etkin, A. (2016). Transdiagnostic impairment of cognitive control in mental illness. Journal of Psychiatric Research, 83, 37–46. http://doi.org/10.1016/j.jpsychires.2016.08.001

McTeague, L. M., Huemer, J., Carreon, D. M., Jiang, Y., Eickhoff, S. B., & Etkin, A. (2017). Identification of common neural circuit disruptions in cognitive control across psychiatric disorders. American Journal of Psychiatry, 174(7), 676-685.

McTeague, L.M., Rosenberg, B.M., Lopez, J.W., Carreon, D.M., Huemer, J., Jiang, Y., Chick, C.F., Eickhoff, S.B. and Etkin, A., (2020) Identification of common neural circuit disruptions in emotional processing across psychiatric disorders. American Journal of Psychiatry, 177(5), 411-421.

Mende-Siedlecki, P., Kober, H., & Ochsner, K. N. (2011). Emotion Regulation: Neural Bases and Beyond. In J. Decety, & J. T. Cacioppo, The Oxford Handbook of Social Neuroscience (pp. 277-292).

Menon, V. (2011). Large-scale brain networks and psychopathology: a unifying triple network model. Trends in cognitive sciences, 15(10), 483-506.

Mitsopoulou, E., Karademas, E. C., Kafetsios, K., & Papastefanakis, E. (2013). The Greek Version of the Difficulties in Emotion Regulation Scale: Testing the Factor Structure, Reliability and Validity in an Adult Community Sample. *Journal of Psychopathology and Behavioral Assessment , 35*, 123–131.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100.

Mocaiber, I., Pereira, M.G., Erthal, F.S., Machado-Pinheiro, W., David, I.A., Cagy, M., Volchan, E. & de Oliveira, L. (2010). Fact or fiction? An event-related potential study of implicit emotion regulation. *Neuroscience Letters*, *476*(2), 84-88.

Moran, T., Jendrusinab, A. A., & Mosera, J. S. (2013). The psychometric properties of the late positive potential during emotion processing and regulation. Brain Research , 15 (16), 66 – 75.

Morris, N., & Jones, D. M. (1990). Memory updating in working memory: The role of the central executive. *British journal of psychology*, *81*(2), 111-121.

Morris, Sarah, E; Cuthber, B. N. (2012). Research Domain Criteria: cognitive systems, neural circuits, and dimensions of behavior. Dialogues in Clinical Neuroscience, 14(1), 29–37.

Moser, J. S., Hajcak, G., Bukay, E., & Simons, R. F. (2006). Intentional modulation of emotional responding to unpleasant pictures: an ERP study. *Psychophysiology*, *43*(3), 292-296.

Moser, J.S., Krompinger, J.W., Dietz, J., Simons, R.F. (2009). Electrophysiological correlates of decreasing and increasing emotional responses to unpleasant pictures. Psychophysiology 46, 17–27.

Muthén, L.K. and Muthén, B.O. (1998-2017). Mplus User's Guide. Eighth Edition. Los Angeles, CA: Muthén & Muthén.

Myers-Schulz, B., & Koenigs, M. (2014). Functional anatomy of ventromedial prefrontal cortex: Implications for mood and anxiety disorders. Molecular Psychiatry, 17(2), 132–141. http://doi.org/10.1038/mp.2011.88.

Naragon-Gainey, K., McMahon, T. P., & Chacko, T. P. (2017). The structure of common emotion regulation strategies: A meta-analytic examination. Psychological Bulletin, 143(4), 384.

National Institute of Mental Health. (2015). Genetics Home Reference. Retrieved from Precision Medicine: https://ghr.nlm.nih.gov/primer/precisionmedicine/

National Institute of Mental Health. (2008). The National Institute of Mental Health Strategic Plan. Retrieved from The National Institute of Mental Health Strategic Plan: http://www.nimh.nih.gov/about/strategic-planning-reports/index.shtml

National Institute of Mental Health. (2018). RdoC Matrix. Retrieved from https://www.nimh.nih.gov/research/research-funded-by-nimh/rdoc/constructs/rdoc-matrix.shtml

Nozaki, Y., & Mikolajczak, M. (2020). Extrinsic emotion regulation. Emotion, 20, 10–15. http://dx.doi.org/10.1037/emo0000636

Ochsner, K. N., & Gross, J. J. (2005). The Cognitive Control of Emotion. TRENDS in Cognitive Sciences , 9 (5), 242-355.

Ochsner, K., & Gross, J. J. (2008). Cognitive Emotion Regulation Insights From Social Cognitive and Affective Neuroscience. Current Directions in Psycological Science , 17 (2), 153-158.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking Feelings: An fMRI Study of the Cognitive Regulation of Emotion. Journal of Cognitive Neuroscience , 14 (5), 1215–1229.

Ochsner, K. N., Ray, R. D., Cooper, J. C., Roberstson, E. R., Chopra, S., Gabrieli, J. D., et al. (2004). For better or for worse: neural systems supporting the cognitive down- and up-regulation of negative emotion. 23, 483–499.

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: a synthetic review and evolving model of the cognitive control of emotion. Annals of the New York Academy of Sciences, 1251, E1-E24.

Opitz, P. C., Gross, J. J., & Urry, H. (2012). Selection, Optimization, and Compensation in the Domain of Emotion Regulation: Applications to Adolescence, Older Age, and Major Depressive Disorder. Social and Personality Psychology Compass , 6 (2), 142–155.

Opitz, P. C., Lee, I. A., Gross, J. J., & Urry, H. L. (2014). Fluid cognitive ability is a resource for successful emotion regulation in older and younger adults. *Frontiers in Psychology*, *5*, 609.

Ottoa, A. R., Raiob, C. M., Chiang, A., Phelps, E. A., & Dawa, N. D. (2013). Working-memory capacity protects model-based learning from stress. PNAS , 110 (5), 20941–20946.

Pan, D. N., Hoid, D., Wang, X. B., Jia, Z., & Li, X. (2020). When expanding training from working memory to emotional working memory: not only improving explicit emotion regulation but also implicit negative control for anxious individuals. *Psychological Medicine*, 1-10.

Parvaz, M. A., MacNamara, A., Goldstein, R. Z., & Hajcak, G. (2012). Event-related induced frontal alpha as a marker of lateral prefrontal cortex activation during cognitive reappraisal. Cognitive, Affective, and Behavioral Neuroscience, 12, 730–740

Patrick, C. J., & Hajcak, G. (2016). RdoC: Translating promise into progress. Psychophysiology, 53, 415–424. http://doi.org/10.1111/psyp.12612

Paul, S., Simon, D., Endrass, T., & Kathmann, N. (2016). Altered emotion regulation in obsessive–compulsive disorder as evidenced by the late positive potential. Psychological Medicine, 46, 137–147.

Pe, L. M., Koval, P., Houben, M., Erbas, Y., Chambpagne, D., & Kuppens, P. (2015). Updating in working memory predicts greater emotion reactivity to and facilitated recovery from negative emotion-elicitings timuli . Frontiers in Psychology , 6 (372), 1-13.

Pe, M. L., Raes, F., & Kuppens, P. (2013). The cognitive building blocks of emotion regulation: Ability to update working memory moderates the efficacy of rumination and reappraisal on emotion. PloS one, 8(7), e69071.

Perez, J., Venta, A., Garnaat, S., & Sharp, C. (2012). The Difficulties in Emotion Regulation Scale: Factor structure and association with nonsuicidal self-injury in adolescent inpatients. *Journal of Psychopathology and Behavioral Assessment*, *34*(3), 393-404.

Phelps, E. A., Delgado, M. R., Nearing, K. I., & Ledoux, J. E. (2004). Extinction Learning in Humans: Role of the Amygdala and vmPFC. Neuron, 43, 897–905.

Phillips, M. L., Ladouceur, C. D., & Drevets, W. C. (2008). A neural model of voluntary and automatic emotion regulation: implications for understanding the pathophysiology and neurodevelopment of bipolar disorder. Molecular Psychiatry, 13(9), 829, 833–57. http://doi.org/10.1038/mp.2008.65

Psychology Software Tools, Inc. [E-Prime 3.0]. (2016). Retrieved from https://www.pstnet.com

Preece, D. A., Becerra, R., Robinson, K., & Gross, J. J. (2019). The emotion regulation questionnaire: psychometric properties in general community samples. *Journal of personality assessment*.

Preece, D.A., Becerra, R., Hasking, P., McEvoy, P.M., Boyes, M., Sauer-Zavala, S., Chen, W. and Gross, J.J. (2021). The Emotion Regulation Questionnaire: Psychometric properties and relations with affective symptoms in a United States general community sample. *Journal of Affective Disorders*, *284*, 27-30.

Proudfit, G. H., Bress, J. N., Foti, D., Kujawa, A., & Klein, D. N. (2015). Depression and event-related potentials: Emotional disengagement and reward insensitivity. Current Opinion in Psychology, 4, 110–113.

Pruessner, L., Barnow, S., Holt, D. V., Joormann, J., & Schulze, K. (2020). A cognitive control framework for understanding emotion regulation flexibility. Emotion, 20(1), 21.

Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. Journal of Experimental Psychology: General, 124, 207–231.

Romer, A. L., Knodt, A. R., Houts, R., Brigidi, B. D., Moffitt, T. E., Caspi, A., & Hariri, A. R. (2018). Structural alterations within cerebellar circuitry are associated with general liability for common mental disorders. *Molecular psychiatry*, *23*(4), 1084-1090.

Roy, M., Shohamy, D., & Wager, T. D. (2012). Ventromedial prefrontal-subcortical systems and the generation of affective meaning. Trends in Cognitive Sciences. Elsevier Ltd. http://doi.org/10.1016/j.tics.2012.01.005

Sanislow, C. A. (2016a). Updating the Research Domain Criteria. World Psychiatry, 15(3), 222-223.

Sanislow, C. A. (2016b). Connecting Psychopathology Meta- Structure and Mechanisms. Journal of Abnormal Psychology, 125(8), 1158–1165.

Sanislow, C. A. (2020). RdoC at 10: changing the discourse for psychopathology. *World Psychiatry*, *19*(3), 311.

Sanislow, C. A., Ferrante, M., Pacheco, J., & Rudorfer, M. V. (2019). Advancing Translational Research Using NIMH Research Domain Criteria and Computational Methods. Neuron, 779-782

Sanislow, C. A., Morris, S. E., Pacheco, J., & Cuthbert, B. N. (2020). The National Institute of Mental Health Research Domain Criteria: An Alternative Framework to Guide Psychopathology Research. In J. R. Geddes, N. C. Andreasen, & G. M. Goodwin, The New Oxford Textbook of Psychiatry (3rd Edition). Oxford: Oxford University Press.

Sanislow, C. A., Pine, D. S., Quinn, K. J., Kozak, M. J., Garvey, M. A., Heinssen, R. K., Sung-En Wang, P., Cuthbert, B. N. (2010). Developing Constructs for Psychopathology Research: Research Domain Criteria. Journal of Abnormal Psychology, 119(4), 631–639.

Schaefer, S. M., Jackson, D. C., Davidson, R. J., Aguirre, G. K., Kimberg, D. Y., & Thompson-Schill, S. L. (2002). Modulation of Amygdalar Activity by the Conscious Regulation of Negative Emotion. Journal of Cognitive Neuroscience , 14 (6), 913–921.

Schiller, D., & Delgado, M. R. (2010). Overlapping neural systems mediating extinction, reversal and regulation of fear. Trends in Cognitive Sciences, 14(6), 268–276. http://doi.org/10.1016/j.tics.2010.04.002

Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. Emotion. 2010 , 10 (5), 739-44.

Schmeichel, B. J., & Tang, D. (2013). The relationship between individual differences in executive functioning and emotion regulation: A comprehensive review. The control within: Motivation and its regulation, 133-52.

Schmeichel, B. J., & Tang, D. (2015). Individual Differences in Executive Functioning and Their Relationship to Emotional Processes and Responses. Current Directions in Psychological Science, 24(2), 93–98. http://doi.org/10.1177/0963721414555178

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working Memory Capacity and the Self-Regulation of Emotional Expression and Experience. Journal of Personality and Social Psychology, , 95 (6), 1526–1540.

Schweizer, S., Grahn, J., Hampshire, A., Mobbs, D., & Dalgleish, T. (2013). Training the Emotional Brain: Improving Affective Control through Emotional Working Memory Training. The Journal of Neuroscience , 33 (12), 5301–5311.

Schweizer, S., Hampshire, A., & Dalgeish, T. (2011). Extending Brain-Training to the Affective Domain: Increasing Cognitive and Affective Executive Control through Emotional Working Memory Training. Plos ONE , 6 (9).

Schweizer, S., Gotlib, I. H., & Blakemore, S. J. (2020). The role of affective control in emotion regulation during adolescence. *Emotion*, *20*(1), 80.

Schweizer, S., Gotlib, I. H., & Blakemore, S. J. (2020). The role of affective control in emotion regulation during adolescence. *Emotion*, *20*(1), 80.

Schweizer, S., Satpute, A. B., Atzil, S., Field, A. P., Hitchcock, C., Black, M., ... & Dalgleish, T. (2019). The impact of affective information on working memory: A pair of meta-analytic reviews of behavioral and neuroimaging evidence. *Psychological bulletin*, *145*(6), 566.

Seeley, S. H., Garcia, E., & Mennin, D. S. (2015). Recent advances in laboratory assessment of emotion regulation. Current Opinion in Psychology, 3, 58–63. http://doi.org/10.1016/j.copsyc.2015.02.009

Seligowski, A. V., & Orcutt, H. K. (2015). Examining the structure of emotion regulation: A factor-analytic approach. Journal of Clinical Psychology, 71, 1004–1022. http://dx.doi.org/10.1002/jclp.22197

Siegle, G. J., Ghinassi, F., & Thase, M. E. (2007). Neurobehavioral Therapies in the 21st Century: Summary of an Emerging Field and an Extended Example of Cognitive Control Training for Depression. Cognitive Therapy Research, 31, pp.235–262.

Sha, Z., Xia, M., Lin, Q., Cao, M., Tang, Y., Xu, K., Song, H., Wang, Z., Wang, F., Fox, P.T. and Evans, A.C. (2018). Meta-connectomic analysis reveals commonly disrupted functional architectures in network modules and connectors across brain disorders. *Cerebral Cortex*, *28*(12), 4179-4194.

Sha, Z., Wager, T. D., Mechelli, A., & He, Y. (2019). Common dysfunction of large-scale neurocognitive networks across psychiatric disorders. *Biological psychiatry*, *85*(5), 379-388.

Siegle, G. J., Ghinassi, F., & Thase, M. E. (2007). Neurobehavioral therapies in the 21st century: Summary of an emerging field and an extended example of cognitive control training for depression. Cognitive Therapy and Research, 31(2), pp. 235–262. http://doi.org/10.1007/s10608-006-9118-6

Silvers, J. A., Buhle, J. T., & Ochsner, K. N. (2014). *The neuroscience of emotion regulation: Basic mechanisms and their role in development, aging, and psychopathology.* In K. N. Ochsner & S. M. Kosslyn (Eds.), *Oxford library of psychology. The Oxford handbook of cognitive neuroscience, Vol. 2. The cutting edges* (p. 52–78). Oxford University Press.

Silvers, J. A., Wager, T. D., Weber, J., & Ochsner, K. N. (2015). The neural bases of uninstructed negative emotion modulation. Social Cognitive and Affective Neuroscience , 10 (1), 10-18.

Sheppes, G., Suri, G., & Gross, J. J. (2015). Emotion regulation and psychopathology. *Annual review of clinical psychology*, *11*, 379-405.

Smith, G. T., Atkinson, E. A., Davis, H. A., Riley, E. N., & Oltmanns, J. R. (2020). The general factor of psychopathology. Annual Review of Clinical Psychology, 16, 75-98.

Snyder, H. R., Miyake, A., & Hankin, B. L. (2015). Advancing understanding of executive function impairments and psychopathology: Bridging the gap between clinical and cognitive approaches. Frontiers in Psychology, 6, March, pp.1–24. http://doi.org/10.3389/fpsyg.2015.00328

Speed, B. C., & Hajcak, G. (2020). Event-Related Potentials and Emotion Dysregulation. In T. P. Beauchaine, & S. E. Crowell, The Oxford Handbook of Emotion Dysregulation (pp. 167-182). New York: Oxford University Press.

Sperduti, M., Makowski, D., Arcangeli, M., Wantzen, P., Zalla, T., Lemaire, S., Piolino, P. (2017). The distinctive role of executive functions in implicit emotion regulation. Acta Psychologica, 173, pp. 13–20. http://doi.org/10.1016/j.actpsy.2016.12.001

Stawski, R. S., Almeida, D. M., Lachman, M. E., Tun, P. A., & Rosnick, C. B. (2010). Fluid cognitive ability is associated with greater exposure and smaller reactions to daily stressors. *Psychology and aging*, *25*(2), 330.

Steer, R. A., Clark, D. A., & Ranieri, W. F. (1994). Symptom dimensions of the SCL-90-R: A test of the tripartite model of anxiety and depression. *Journal of Personality Assessment, 62*, 525-536.

Steward, T., Davey, C. G., Jamieson, A. J., Stephanou, K., Soriano-Mas, C., Felmingham, K. L., & Harrison, B. J. (2021). Dynamic Neural Interactions Supporting the Cognitive Reappraisal of Emotion. *Cerebral Cortex*, *31*(2), 961-973.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of experimental psychology*, *18*(6), 643.

SurveyMonkey Inc, San Mateo, California, USA, URL: www.surveymonkey.com

Sun, M., Vinograd, M., Miller, G. A., & Craske, M. G. (2017). Research domain criteria (RDoC) and emotion regulation. In C. A. Essau, S. LeBlanc, & T. H. Ollendick (Eds.), Emotion regulation and psychopathology in children and adolescents (pp. 79–110). Oxford: Oxford University Press.

Tackett, J. L., Lahey, B. B., Van Hulle, C., Waldman, I., Krueger, R. F., & Rathouz, P. J. (2013). Common genetic influences on negative emotionality and a general psychopathology factor in childhood and adolescence. Journal of abnormal psychology, 122(4), 1142-1153.

Tang, Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. Nature Reviews Neuroscience, 16(4), pp. 213–225. http://doi.org/10.1038/nrn3916

Tang, D., & Schmeichel, B. J. (2014). Stopping anger and anxiety: Evidence that inhibitory ability predicts negative emotional responding. Cognition & Emotion, 28, 132–142.

Theodorou, C., Ioannou, M., Karekla, M., & Panayiotou, G. (In prep.). Examining the factors of the Psychiatric Diagnostic Screening Questionnaire (PDSQ).

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. Monographs of the society for research in child development, 25-52.

Thiruchselvam, R., Blechert, J., Sheppes, G., Rydstrom, A. & Gross, J. J. (2011). The temporal dynamics of emotion regulation: An EEG study of distraction and reappraisal. *Biological Psychology , 87*, 84–92.

Torre, J. B., & Lieberman, M. D. (2018). Putting feelings into words: Affect 120abelling as implicit emotion regulation. *Emotion Review*, *10*(2), 116-124.

Tottenham, N., Tanaka, J., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Marcus, D.J., Westerlund, A., Casey, B.J., Nelson, C.A. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, 168(3), pp. 242-9.

Tran, T. B., Siemer, M., & Joormann, J. (2011). Implicit interpretation biases affect emotional vulnerability: a training study. Cognition & Emotion, 25(3), pp. 546–558. http://doi.org/10.1080/02699931.2010.532393

Tupak, S. V., Dresler, T., Guhn, A., Ehlis, A. C., Fallgatter, A. J., Pauli, P., & Herrmann, M. J. (2014). Implicit emotion regulation in the presence of threat: Neural and autonomic correlates. NeuroImage, 85, pp. 372–379. http://doi.org/10.1016/j.neuroimage.2013.09.066

Urry, H. L., van Reekum, C. M., Johnstone, T., Kalin, N. H., Thurow, M. E., Schaefer, H. S., et al. (2006). Amygdala and Ventromedial Prefrontal Cortex Are Inversely Coupled during Regulation of Negative Affect and Predict the Diurnal Pattern of Cortisol Secretion among Older Adults. The Journal of Neuroscience , 26 (16), pp. 4415– 4425.

Uusberg, A., Taxer, J. L., Yih, J., Uusberg, H., & Gross, J. J. (2019). Reappraising reappraisal. Emotion Review, 11(4), 267-282.

Uusberg, A., Uusberg, H., & Gross, J. J. (2020). How can emotions be regulated? In A. Scarantino (Ed.), Routledge Handbook of Emotion Theory. New York, NY: Routledge.

Vanderhasselt, M. A., Brunoni, A. R., Loeys, T., Boggio, P. S., & De Raedt, R. (2013). Nosce te ipsum–Socrates revisited? Controlling momentary ruminative self-referent thoughts by neuromodulation of emotional working memory. Neuropsychologia, 51(13), 2581-2589.

Vaidyanathan, U., & Pacheco, J. (2017). Research Domain Criteria Constructs: Integrative reviews and empirical perspectives. Journal of Affective Disorders, 216, 1-2.

Vinogradov, S., Fisher, M., & de Villers-Sidani, E. (2012). Cognitive Training for Impaired Neural Systems in Neuropsychiatric Illness. Neuropsychopharmacology, 37(1), 43–76. http://doi.org/10.1038/npp.2011.251

von Hippel, W., & Gonsalkorale, K. (2005). "That is bloody revolting!" Inhibitory control of thoughts better left unsaid. *Psychological Science*, *16*(7), 497-500.

Weinberg, A., Venables, N. C., Proudfit, G. H., & Patrick, C. J. (2015). Heritability of the neural response to emotional pictures: Evidence from ERPs in an adult twin sample. Social, Cognitive, and Affective Neuroscience, 10, 424–434.

Xiu, L., Wu, J., Chang, L., & Zhou, R. (2018). Working memory training improves emotion regulation ability. *Scientific reports*, *8*(1), 1-11.

Yntema, D. B. (1963). Keeping track of several things at once. Human Factors, 5, 7–17.

Zelazo, P. D. (2020). Executive Function and Psychopathology: A Neurodevelopmental Perspective. Annual Review of Clinical Psychology, 16.

Zelazo, P. D., & Cunningham, W. (2007). Executive function: Mechanisms underlying emotion regulation. In Handbook of emotion regulation (pp. 135-158). Guilford

Zimmerman, M., & Mattia, J. I. (2001a). A Self-Report Scale to Help Make Psychiatric Diagnoses: The Psychiatric Diagnostic Screening Questionnaire. *Arch Gen Psychiatry* , *58*, 787-794.

Zimmerman, M., & Mattia, J. I. (2001b). The Psychiatric Diagnostic Screening Questionnaire: Development, Reliability and Validity. *Comprehensive Psychiatry , 42* (3), 175-189.

Greek References:

Ντώνιας Σ, Καραστεργίου Α, & Μάνος Ν. (1991). Στάθμιση της κλίμακας ψυχοπαθολογίας Symptom Checklist -90-R σε Ελληνικό πληθυσμό. *Ψυχιατρική, 2*, 42-48.

Σταλίκας, Α., Τριλίβα, Σ., & Ρούσση, Π. (2012*). Τα Ψυχομετρικά Εργαλεία στην Ελλάδα: Μια συλλογή και παρουσίαση των ερωτηματολογίων, δοκιμασίων και καταλόγων καταγραφής χαρακτηριστικών στον ελληνικό κόσμο. Νέα επαυξημένη και βελτιωμένη έκδοση. Αθήνα: Πεδίο.*

APPENDICES

sTable 2 : Study 1’s Siginfant and marginally significant Correlations

Variable	n	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1.LettMemory	120	.61.80	.14.53	-																								
2. KeepTrack	120	.70.27	.10.14	.40**	-																							
3.Antisaccade	120	89.53	12.86	.22**	.23*	-																						
4. Stroop	120	-133.2	112.17	.28**		.37**	-																					
5.NumbLetter	120	-126.7	92.13	.16 p=0.08		.22*	.16 p=0.08	-																				
6. Category Switch	120	-122.8	96.83			.17 p=0.07	.35**	.35**	-																			
7. Distract Arousal	120	.321	.582					-.17 p=0.07		-																		
8. Reappraise Arousal	120	.220	.526	.19*		.18 p=0.051				.28**	-																	
9. Sup-ress Arousal	120	.306	.705	.20*					.17 p=0.06	.51**	.36**	-																
10. Suppress Valence	120	.376	.636							.53**	.45**	.71**	-															
11.Reappraise Valence	120	.382	.658	.20*		.19*	.22*			.36**	.55**	.28**	.46**	-														
12. Distract Valence	120	.454	.722				.16 p=0.07			.70**	.35**	.56**	.67**	.54**	-													
13. Implicit ER	120	-14.21	63.35								.					-												
14. ERQ Reappraise	120	22.49	4.97			-.21**		-.18*	-.33**			.17 p=0.06					-											
15. DERS	120	81.11	21.41														-.46**	-										
16.ERQ Suppress	120	10.28	3.35					.16 p=0.08										.19*	-									
17.PDSQ	120	.55	.50			.17 p=0.06										.16 p=0.09	-.20*	.45**		-								
18.PDSQ+.	120	.63	.48									.15 p=0.09				.16 p=0.09	-.17 p=0.06	.37**		.84**	-							
19.SCL-90	120	.33	.47								-.23*						-.27*	.51**	.16 p=0.07	.39**	.39**	-						
20. SCL-90+	120	.38	.48								-.19*						-.25**	.48**		.47**	46**	.90**	-					
21. WM Average	120	66.03	10.39	.89**	.77**	.27**	.26**				.21*	.18*	.17 p=0.07											-				
22. Inhibition Average	120	-21.81	58.80	.29**		.47**	.99*	.18 p=0.053	.35**					.23**	.15 p=0.09					.15 p=0.09				.28**	-			
23. Shiftig Average	120	- 124.73	76.61	17 p=0.06		.24**	.32**	.80**	.82**			.19*					-.32**		.18*						.33**	-		
24. ER average valence	120	.404	.565	.17 p=0.07			.20*			.64**	.53**	.61**	.84**	.79**	.89**									.18*	.20*		-	
25.ER average arousal	120	.282	.469	.24**						.78**	.68**	.85**	.74**	.50**	.70**									.23*			.77**	-

** p<0.01

* p< 0.05

Table 3: Confirmatory Factory Analysis's Variable's Indicators and Metrics

Latent Variable	Indicator 1	Metric	Indicator 2	Metric	Indicator 3	Metric
1.Inhibition	Antisaccade (Hallett, 1978)	Average Accuracy 0-100%	Stroop (Stroop, 1935)	Difference Between Reaction Times among Conditions		
2.Shifting	Number Letter (Rogers & Monsell, 1995)	Difference Between Reaction Times among Conditions	Category Switch (Mayr & Kliegl, 2000)	Difference Between Reaction Times among Conditions		
3.Updating	Letter Memory (Morris & Jones, 1990)	Average Accuracy 0-100%	Keep Track (Yntema, 1963)	Average Accuracy 0-100		
4.Psychopathology	PDSQ (Zimmerma &Mattia, 2001)	Yes/No Responses (Total Score) *participants scores led to their subsequent categorisation in two groups (1= existence of affective disorder, 0 =No affective Disorder) ➔ Binary variable	SCL-90-R Derogatis1994	5-point Likert scale (Total Score) *participants scores led to their subsequent categorisation in two groups (1= existence of affective disorder, 0 =No affective Disorder) ➔ Binary variable		

Latent Variable	Indicator 1	Metric	Indicator 2	Metric	Indicator 3	Metric
5.Explicit Emotion Regulation – Behavioural Measures	Reappraisal Valence Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition)	Reappraisal Arousal Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition)	Suppression Valence Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition)
	Indicator 4	**Metric**	**Indicator 5**	**Metric**	**Indicator 6**	**Metric**
	Suppression Arousal Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition	Distraction Valence Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition)	Distraction Arousal Measures on Explicit ER Task (Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011)	9-point Likert scale (Difference with Watch Condition)

Latent Variable	Indicator 1	Metric	Indicator 2	Metric	Indicator 3	Metric
6. Emotion Regulation - Psychometric Measures 1	The ERQ's Reappraisal Subscale (Gross & John, 2003)	7-point Likert scale (Total Score)	DERS's Acceptance Subscale (Gratz & Roemer, 2004)	5- point Likert scale (Total Score)	DERS's Goals Subscale (Gratz & Roemer, 2004)	5- point Likert scale (Total Score)
	Indicator 4	**Metric**	**Indicator 5**	**Metric**	**Indicator 6**	**Metric**
	DERS's Impulse Subscale (Gratz & Roemer, 2004)	5- point Likert scale (Total Score)	DERS's Strategies Subscale (Gratz & Roemer, 2004)	5- point Likert scale (Total Score)	DERS's Clarity Subscale (Gratz & Roemer, 2004)	5- point Likert scale (Total Score)
	Indicator 1	**Metric**	**Indicator 2**	**Metric**	**Indicator 3**	**Metric**
7. Emotion Regulation - Psychometric Measures 2	The ERQ's Suppression Subscale (Gross & John, 2003)	7-point Likert scale (Total Score)	DERS's Awareness Subscale (Gratz & Roemer, 2004	5- point Likert scale (Total Score)	DERS's Clarity Subscale (Gratz & Roemer, 2004	5- point Likert scale (Total Score)
Single Indicator						
1. Implicit ER	Emotional Conflict Adaptation Task – Emotional Stroop (Egner, Etkin, Gale & Hirsch, 2008)	Difference Between Reaction Times among Conditions				

Table 4: Confirmatory Factory Analysis' Significant Correlations

Latent Variable	1	2	3	4	5	6	7
1. ER Behavioral	-						
2. ER Questionnaires 1		-					
3. ER Questionnaires 2			-				
4.Psychopatholoy		-.60**	.31*	-			
5. Shifting***					-		
6. Inhibition					.47**	-	
7. Working Memory	.24 p=0.06					.44**	-

***Significant correlation with Indicator ERQ Reappraisal (r= - .45 p<0.01)

** p <0.01

* p < 0.05

Table 5: Unstandardized Estimators of Parameters for Confirmatory Factory Analysis

	Estimate	S.E.	Est./S.E.	P-Value
ER Behavioural BY				
Suppresion valence	1.000	0.000	999.000	999.000
Reappraisal valence	0.749	0.131	5.696	0.000
Distraction valence	1.044	0.155	6.724	0.000
Reappraisal arousal	0.604	0.120	5.017	0.000
Suppression arousal	0.826	0.096	8.644	0.000
Distraction arousal	0.822	0.144	5.726	0.000
ER Questionnaires 1 BY				
ERQ Reappraisal	1.000	0.000	999.000	999.000
DERS Nonacceptance	-1.676	0.333	-5.027	0.000
DERS Goals	-1.611	0.322	-5.002	0.000
DERS Impulse	-1.597	0.321	-4.978	0.000
DERS Strategies	-1.859	0.347	-5.361	0.000
DERS Clarity	-1.118	0.268	-4.165	0.000
ER Questionnaires 2 BY				
DERS Awareness	1.000	0.000	999.000	999.000
ERQ Suppression	0.539	0.198	2.720	0.007
DERS Clarity	0.810	0.275	2.942	0.003
Psychopathology BY				
PDSQ	1.000	0.000	999.000	999.000
SCLA-90-R	1.199	0.181	6.608	0.000
Shifting BY				
Category Switch	1.000	0.000	999.000	999.000
Number Letter	0.518	0.164	3.153	0.002

Inhibition BY				
Antisaccade	1.000	0.000	999.000	999.000
Stroop	1.831	0.749	2.444	0.015

Working Memory BY				
Letter Memory	1.000	0.000	999.000	999.000
Keeptrack	0.632	0.283	2.236	0.025

Table 6: *Standartised* Estimators of Parameters for Confirmatory Factory Analysis

	Estimate	S.E.	Est./S.E.	P-Value
ER Behavioural BY				
Suppression Valence	0.797	0.090	8.842	0.000
Reappraisal Valence	0.597	0.092	6.509	0.000
Distraction Valence	0.833	0.090	9.257	0.000
Reappraisal Arousal	0.482	0.098	4.932	0.000
Suppression Arousal	0.659	0.096	6.891	0.000
Distraction Arousal	0.655	0.096	6.858	0.000
ER Questionnaires1 BY				
ERQ Reappraisal	0.472	0.090	5.217	0.000
DERS Non Acceptance	-0.790	0.078	-10.081	0.000
DERS Goals	-0.760	0.080	-9.523	0.000
DERS Impulse	-0.753	0.080	-9.365	0.000
DERS Strategies	-0.877	0.074	-11.799	0.000
DERS Clarity	-0.527	0.090	-5.865	0.000
ER Questionnaires 2 BY				
DERS Awareness	0.673	0.136	4.937	0.000
ERQ Suppression	0.363	0.112	3.238	0.001
DERS Clarity	0.545	0.113	4.844	0.000
Psychopathology BY				
PDSQ	0.761	0.091	8.381	0.000
SCL-90-R	0.912	0.091	10.055	0.000
Shifting BY				
Category Switch	0.749	0.134	5.575	0.000
Number Letter	0.388	0.099	3.907	0.000

Inhibition BY				
Antisaccade	0.451	0.122	3.701	0.000
Stroop	0.826	0.174	4.742	0.000

Working Memory BY				
Letter Memory	0.793	0.186	4.257	0.000
Keep Track	0.501	0.137	3.653	0.000

Table 7: Mean Difference among LPP components of each Condition for the entire image duration

Instruction 1	Instruction 2	Mean Difference	Standard Error	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Instruction view	Instruction Watch	-374.341	783.593	-2628.197	1879.515
Instrution View	Instruction Reappraise	-1434.353	1187.643	-4850.382	1981.677
Instrution View	Instruction Suppress	-914.274	1146.113	-4210.850	2382.301
Instrution View	Instruction Distract	-3741.056	1384.603	-2628.197	1879.515

Table 8 : *List of Emotional Words including in eWM Training* (Taken with permission by Schweizer, Grahn, Hampshire, Mobbs & Dalgleish, 2013, and adapted and translated in Greek).

Negative Words:

1. μόνος
2. απελπισμένος
3. αποτυχία
4. μοναχικός
5. αυτοκτονία
6. άχρηστος
7. μελαγχολία
8. θάνατος
9. καταθλιπτικός
10. ένοχος
11. μοναξιά
12. απορρηφθείς
13. νεκρός
14. κατάθλιψη
15. αποτυχημένος
16. κακοποίηση
17. αγωνιώδης
18. επιβαρυμένος
19. φοβισμένος
20. αγχωμένος
21. αβοήθητος
22. παρανοϊκός
23. μιζέρια
24. φορτισμένος
25. ντροπιασμένος
26. ταραγμένος
27. απογοητεύω
28. επώδυνος
29. εξευτελίζω
30. δυστυχισμένος
31. θυμωμένος
32. κρίση
33. αποκομμένος
34. φοβιτσιάρης
35. πένθος
36. πληγωμένος
37. κατώτερος
38. οδύνη
39. θυμός
40. προδίδω
41. φέρετρο
42. στεναχωρημένος
43. φρικτός
44. πικραμένος
45. φόβος
46. ανόητος
47. ανασφαλής
48. εξοργισμένος
49. νευρωτικός
50. τιμωρία
51. λυπημένος
52. τρομαγμένος
53. ηλίθιος
54. τρομοκρατημένος
55. επιθετικός
56. απώλεια
57. δειλός
58. βίαιος
59. κίνδυνος
60. ηττημένος
61. συμφορά
62. ματαιωμένος
63. πανικός
64. παράλυση
65. μετανοιωμένος
66. κραυγή
67. ατύχημα
68. πόνος
69. κομματιασμένος
70. βάναυσος
71. νεκροταφείο
72. συντετριμμένος
73. ζημιά
74. βόμβα
75. αποθαρρύνω
76. αμήχανος
77. κηδεία
78. τρελός
79. παραμέληση
80. γελοιοποιώ
81. άρρωστος
82. τραύμα
83. φαρμάκι
84. συγχισμένος
85. πτώμα
86. δυσφορία
87. πνίγω
88. παραιτώ
89. μισώ
90. ανίκανος
91. τεμπέλης
92. νεκροτομείο
93. οίκτος
94. εφιάλτης
95. βιασμός
96. αρρώστια
97. ασφυξία
98. έκτρωση
99. επίθεση
100. ταφή
101. καρκίνος
102. περιφρόνηση
103. σταυρώνω
104. αηδιασμένος
105. οδυνηρός
106. σφάλμα
107. αδύναμος
108. σκληρός
109. έχθρα
110. πονοκέφαλος

111. τρόμος
112. ασθένεια
113. εκνευρίζω
114. μανιακός
115. εκδίκηση
116. νευρικός
117. σφαγή
118. βασανίζω
119. τοξικός
120. τραγωδία
121. προβληματισμένος
122. άσχημος
123. μοχθηρός
124. ενοχλώ
125. παρενοχχλώ
126. μισητός
127. απάτη
128. απεχθάνομαι
129. καταστροφή
130. εξαγριωμένος
131. κακό
132. θλιβερός
133. αισχρός
134. όπλο
135. ταλαιπωρία
136. ακρωτηριάζω
137. κόλαση
138. εχθρικός
139. προσβολή
140. θλίψη

Table 8 *(continued)*

Neutral Words:

1.	ταξί
2.	πόδι
3.	ουδέτερος
4.	πόρτα
5.	βαρέλι
6.	ντουλάπι
7.	μελάνι
8.	ψαλίδι
9.	αγελάδα
10.	καρέκλα
11.	βροχή
12.	κορμός
13.	μαγειρεύω
14.	συσκευή
15.	καλώδιο
16.	μαντήλι
17.	αγκώνας
18.	ρολόι
19.	περιοδικό
20.	βάλτος
21.	δεξαμενή
22.	ομπρέλα
23.	στήλη
24.	φάση
25.	άγαλμα
26.	ντουλαπάκι
27.	εργαλείο
28.	υπολογιστής
29.	πλαίσιο
30.	γιατρός
31.	μηχανή
32.	φελλός
33.	βραστήρας
34.	μολύβι
35.	σανός
36.	κανάτα
37.	γκαζόν
38.	γιλέκο
39.	τσιμπιδάκι
40.	τεμάχιο
41.	αστράγαλος
42.	πέρασμα
43.	πηγούνι
44.	αυγό
45.	δάχτυλο
46.	πιρούνι
47.	παράλληλος
48.	καστανός
49.	ύφασμα
50.	λεκάνη
51.	βούτυρο
52.	κύκλος
53.	μπράτσο
54.	αφίσα
55.	κίτρινος
56.	βαγόνι
57.	τέταρτο
58.	πανό
59.	λάμπα
60.	βιολί
61.	ανελκυστήρας
62.	καλάθι
63.	βλέπω
64.	τοποθετώ
65.	καπέλο
66.	πύργος
67.	φορτηγό
68.	λεωφόρος
69.	βιβλίο
70.	συγγραφέα