MASTER'S IN PSYCHOLOGY THEMES

NEUROCOGNITION AND LANGUAGE

Electrodermal Activity and Expressive Writing: Looking at Skin Conductance level, Individual Differences and Emotions

Setareh Fadaei

M

2020

Universidade do Porto
Faculdade de Psicologia e de Ciências da Educação

Electrodermal Activity and Expressive Writing: Looking at Skin Conductance level, Individual Differences and Emotions

Setareh Fadaei

September 2020

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Master's Degree in Psychology, at the Department of Psychology and Educational Sciences of the University of Porto, advised by Professor Doctor *Rui Alexandre Alves* (FPCEUP)

Lega Warnings

The content of this dissertation reflects the perspectives, the work and the interpretations of the author at the time of its delivery. This dissertation may contain both conceptual and methodological inaccuracies, which may be identified at a later date. Therefore, any use of its contents should be exercised with caution.

By submitting this dissertation, the author declares that it is the result of her own work, that it contains original contributions and that all sources used are acknowledged, and that such sources are duly cited in the body of the text and identified in the reference section. The author also declares that in this dissertation she is not publishing any content whose reproduction is prohibited by copyright or industrial property rights.

Acknowledgments

It was with the help of my professors, my friends and family that I accomplished this two-year journey of getting my Master's degree. I want to express my gratitude to my adviser and professor, Rui Alexandre Alves, for his orientation and support for writing this dissertation and giving me the confidence that every idea, as long as it is scientific, is valuable and important. Also, I want to thank professor Manuel Fernando dos Santos Barbosa for his help with the software analyses and interpretations of the data.

Without the help of Teresa Jacques de Figueiredo Moutinho it would be very hard and confusing to complete this dissertation, I would like to thank her for all of her support, understanding and help in the data collection, processing and improvement of this dissertation.

In addition, I would like to thank Gordon Grams and Mitra Kholousi for all their help in the proofreading this paper.

Most of all, in the end I would like to express may gratitude to my family and especially to my grandfather (Babazia), who although are living far away accompanied me during these two years with their love and reassurance. They made me believe that with continuous effort I could overcome the challenges, and more important than doing things perfectly, is that I do them out of joy. Although it was a challenging path, I enjoyed every step of it.

Abstract

Traumatic events in life are typically accompanied by concealed emotions. Writing about traumas can release these emotions and help to regulate them. Despite available knowledge about the effect of expressive writing on health and emotion regulation, principal autonomic influence of expressive writing on emotions, physical changes and individual differences are not clear yet. By analyzing electrodermal activity (EDA) throughout writing, we studied this research topic. To study correlations between expressive writing, bodily changes and individual differences, 57 first year university students were randomly assigned to a control or expressive group, completing a neutral or emotional writing task, respectively. Real-time psychophysiological data was recorded during writing (5 min. baseline; 15 min. writing task; 5 min. post-writing), to examine the psychophysiological and emotional changes. Results showed that participants in the expressive group had higher negative affect compared to the control group after finishing the task. Also, that upon starting the writing task and after finishing it (post-writing), regardless of the writing topic (neutral or expressive), EDA rose. Reward-seeking is a possible reason for the post-writing rise of EDA in both groups. Additionally, results revealed that extroverts showed lower EDA compared to introverts 5 minutes after starting the writing task likely due to habituation. These findings shed light on the autonomic influences during writing and its effect on emotions, and also, how these can be influenced by individual differences in personality.

Keywords: electrodermal activity, expressive writing, individual differences and emotions

Funding: This dissertation was conducted within the research project: "Mind-Body Interactions in Writing" (M-BW), funded by BIAL Foundation (Grant 312/16).

Resumo

Eventos traumáticos são acompanhados por emoções desconhecidas. Escrever sobre traumas pode liberar essas emoções e ajudar a regulá-las. Apesar do conhecimento disponível sobre o efeito da escrita expressiva na saúde e na regulação emocional, a principal influência autonómica da escrita expressiva nas emoções, mudanças físicas e diferenças individuais ainda não são claras. Ao analisar a atividade eletrodérmica (EDA) ao longo da escrita, estudamos estes tópicos de investigação. Para estudar as correlações entre escrita expressiva, mudanças corporais e diferenças individuais, 57 estudantes universitários do primeiro ano foram aleatoriamente distribuídos por um grupo de controlo ou expressivo, completando uma tarefa de escrita neutra ou emocional, respectivamente. Os dados psicofisiológicos em tempo real foram registrados durante a escrita (5 min. Linha de base; 15 min. Tarefa de escrita; 5 min. Pós-escrita), para examinar as mudanças psicofisiológicas e emocionais. Os resultados mostraram que os participantes do grupo expressivo tiveram maior afeto negativos em relação ao grupo controlo após terminar a tarefa. Além disso, ao iniciar a tarefa de escrita e ao finalizá-la (pós-escrita), independentemente do tópico, o EDA aumentou. A busca de recompensas é uma possível razão para o aumento pós-escrita do EDA em ambos os grupos. Adicionalmente, os resultados revelaram que os extrovertidos apresentaram menor EDA em comparação aos introvertidos 5 minutos após o início da tarefa de escrita, provavelmente devido ao efeito de habituação. Essas descobertas aumentam o conhecimento sobre as influências do sistema nervoso autónomo durante a escrita e seu efeito nas emoções, e também, como estes podem ser influenciadas por diferenças individuais na personalidade.

Palavras-chave: atividade eletrodérmica, escrita expressiva, diferenças de personalidade e emoções

Financiamento: Esta dissertação de mestrado foi realizada dentro do projeto de investigação: "Mind-Body Interactions in Writing” (M-BW), financiado pela fundação BIAL (Grant 312/16)

Index of tables

Index of figures

Index

1. Introduction

A common observation is that individuals tend to sweat not only when it is hot, but also when facing emotional events. This occurs because humans have sweat glands in their bodies, which besides controlling for body temperature are also activated by emotional situations. Such situations can be triggered by expressive writing. In expressive writing one writes about one's deepest feelings and thoughts which conceivably can help to trigger restrained emotional responses (Pennebaker & Beall, 1986). Expressive writing could, therefore, activate the sympathetic nervous system, which can be measured by changes in electrodermal activity (EDA) on the palmer sweat glands. Furthermore, EDA could also be influenced by individual differences such as extroversion or introversion, empathy, anxiety and depression, when individuals are using expressive writing. Broadly put, in this dissertation we investigate factors affecting EDA during an expressive writing exercise.

1.1. Electrodermal activity

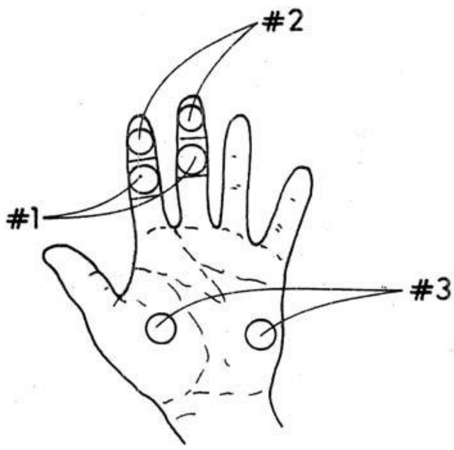
The discovery of EDA is commonly attributed to Roman Vigouroux in the late XIX century, but the intensive research in this area started in the early XX century with an experiment by Veraguth and Jung on word association (see Neumann & Blanton, 1970). From that time until now this measurement has often been used in psychological and physiological experiments (Boucsein et al., 2012). Studies on patients with brain lesions indicated that damage to prefrontal cortex–especially ventromedial prefrontal cortex–and limbic system–mostly the amygdala and hippocampus–is associated with lower EDA responses, showing that these areas are involved in EDA activation (Critchley, 2002). These mentioned areas are under the effect of the sympathetic nervous system (SNS). EDA is a direct measure of SNS which is not contaminated by the parasympathetic nervous system (PSNS; Dawson, Schell & Filion, 2007). For this reason, electrodermal activity of palmer sweat glands are measured in psychophysiological studies to evaluate SNS activation.

There are two types of sweat glands in the human body, eccrine and apocrine, which are responsible for both thermal control and emotional related sweating. Palmar sweat glands are eccrine glands, which compared to other sweat glands in the body are more responsive to psychological stimuli (Shields, MacDowell, Fairchild & Campbell, 1987).

EDA is measured in microsiemens (μs) and it is collected by placing two electrodes on active sites (bipolar measurement) and delivering a stable electrical voltage (0.05v). As shown in Figure 1.1, there are three common places on the hand for placing electrodes. Volar surface of the medial and distal phalanges on the finger (#1, #2) and thenar and hypothenar eminences of the palm (#3). For most studies the distal phalange site is used because it is easier to measure EDA and it does not sweat as much as the thenar eminences (Dawson, Schell & Filion, 2007). Nowadays an EDA measurement can be provided by wristbands, thus allowing data collection during longer periods of time and in a more natural way (Poh, Swenson & Picard, 2010).

Figure 1.1.

Three electrode placements for recording electrodermal activity

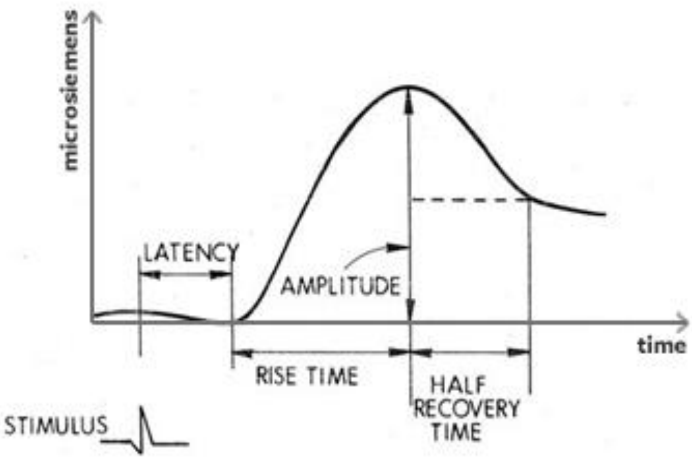


Note. Placement #1 involves volar surfaces on medial phalanges, placement #2 involves volar surfaces of distal phalanges, and placement #3 involves thenar and hypothenar eminences of palms. Copied from "The electrodermal system." by Dawson, M. E., Schell, A. M., & Filion, D. L, 2007, *Handbook of Psychophysiology*, *2*, 200-223, p.163.

EDA is measured by three different metric parameters: non-specific skin conductance responses (NS-SCR), the electrodermal activity at rest without the presence of any stimulus; skin conductance level (SCL), the slowly changing tonic level, and skin conductance responses (SCR), the fast-varying phasic activities that change in the face of a stimulus (Benedek, & Kaernbach, 2010; Dawson, Schell and Filion, 2007). A short period after presenting the stimulus (latency, between 1 to 4 seconds), skin conductivity will raise, till it reaches its peak amplitude (raise time, which normally varies between 0.5 to 5 seconds). Then, it will slowly drop to almost half of the amplitude (half recovery time; Boucsein et al., 2012). These components can be seen in Figure 1.2.

Figure 1.2.

Graphical representation of principal EDA components.



Note. Adapted from "The electrodermal system." by Dawson, M. E., Schell, A. M., & Filion, D. L, 2007, *Handbook of Psychophysiology*, *2*, 200-223, p.165

As EDA is connected to cognitive states, arousal, emotion and attention; it is useful for measuring unconscious emotional responses like threat, anticipation and individual differences (Braithwaite, Watson, Jones & Rowe, 2013; Dawson, Schell & Filion, 2007). In an interesting study on EDA changes during piano performance, T. Dean and Bailes (2015) found that even silent playing, can cause changes in EDA, justifying its role as a possible measure for attention and arousal.

Wood, Jepson and Stadler (2018) conducted a study related on EDA and recalling memories within a social group. They recorded EDA during a one-hour session of art and craft activities. A week after the art session participants were asked to talk about their experience, emotions and their happiest memories related to the activity while their EDA was measured again. Findings showed that by remembering emotions and experiences, participants had similar EDA raises as in the activity itself. Remembering shared emotional memories can not only make changes in EDA similar to the event itself, but also make stronger EDA increases in people who are remembering the event together. Wood and Kenyon (2018) in their case study of a friendship pair talking about the importance of shared emotional event experiences, found that sharing memories and remembering them together triggers not only changes in EDA, but also make it more intense compared to the real event.

1.2. Expressive Writing

Expressive writing involves writing about emotions and intimate thoughts. More than just a means of communication, writing can be a way to express emotions, feelings and intimate ideas (Lepore, Greenberg, Bruno, & Smyth, 2002). A considerable number of studies indicated that putting emotions into language has positive impacts on physical, social and psychological wellbeing (Pennebaker & Chung, 2007). Pennebaker and Beall (1986) conducted a study about the effect of expressive writing on health where participants were asked to write about a traumatic event of their lives. They wrote about thoughts and emotions related to a trauma or about superficial topics for four days, 15 minutes each day. Results showed that writing about traumas was initially accompanied by negative emotions, but later was associated with long-term health benefits, such as fewer visits to the health center and less aspirin use. In another study by Lepore (1997) on depressive symptoms related to an important academic examination, participants in the expressive writing group wrote about their deepest thoughts and emotions related to the exam and presented lower depressive symptoms than the control group, who wrote about trivial topics. In this case expressive writing did not reduce the amount of negative thoughts but attenuated their negative emotional effect.

In relation to expressive writing and EDA, very few studies are available. In a study about the effect of expressive writing on the immune system (Petrie et al., 1995) participants wrote 15 minutes daily during four consecutive days about the most traumatic and upsetting experience in their lives (expressive group) or about their daily routine (control group) while EDA was measured. Results showed that EDA had a significant continuous decrease in the expressive group upon four days of writing compared to the control group which had continuous increase in EDA starting from the second day of writing assignment. Moreover, participants in the expressive group had more antibodies against the hepatitis B vaccine compared to controls. McGuire, Greenberg and Gevirts (2005) had different findings related to the effect of expressive writing on EDA. Individuals with elevated blood pressure were grouped in expressive or control group (writing about the most traumatic event or daily routine, respectively) and wrote 15 minutes daily during four consecutive days. EDA was measured before and two weeks after the writing session. Their results showed that expressive writing helped to decrease blood pressure, but there were no differences in the EDA of the expressive and control groups after four days.

1.3. Individual differences

As a collection of traits, personality varies across individuals. These differences can be influenced by genes or social environment, like family, friends and school (Harris, 2011). Individuals can also vary in empathy and in the extent to which they feel anxiety or depression.

The Big Three. A wide variety of trait theories and measurement scales have been developed. Currently the Big Three, a theory developed by Eysenck (1985), is a widespread one and identifies three main traits in personality. Extrovert or introvert, neurotic or stable, psychoticism or adjusted personality, each of these dimensions is like a continuum between two idealized extremes (Almiro, Moura & Simões, 2016). Extroverts are less aroused by external stimulation than introverts, who can be more easily aroused because of their neurologically lower threshold of arousal (Geen, 1984). A neurotic personality is characterized by emotional instability, which contrasts with a stable personality. Psychoticism is defined as being aggressive, cold and insensitive, and is in contrast to an adjusted personality which is characterized as being empathic, warm and friendly (Almiro, Moura & Simões, 2016). One of the instruments to measure personality differences is the Eysenck Personality Questionnaire-Revised (EPQ-R). This is a self-report questionnaire and has three dimensions: extroversion (E), neuroticism (N) and psychoticism (P; Eysenck, 1991).

EDA is correlated with individual differences. Individuals who have labile EDA are likely to be more calm, responsible and cooperative while individuals with stable EDA are more active, assertive and antagonistic (Crider, 1993). Also, there is a difference in EDA between extroverts and introverts. Extroverts are less aroused and as a result their EDA is typically lower than that of introverts (Smith, 1983; Zvi & Elaad, 2016). On the other end, neuroticism is related with higher EDA changes (Coles, Gale & Kline, 1971), contrary to psychopaths which EDA changes are lower than in non-psychopaths (Fung et al., 2005).

Empathy. Understanding the needs and feelings of others is called empathy. Individuals are different in relation to empathic behavior and feelings, and as a result they react differently in the face of situations where empathy is needed (Davis, 1983). Empathy is a part of emotional intelligence and it varies in each person (Besel & Yuille, 2010). It is an active cognitive attempt to get inside another person, to understand the feelings of others and to imitate their situation (Davis, 2018). Empathy has cognitive and emotional dimensions. The cognitive is to imagine yourself in the situation of the other person, and the emotional is to understand feelings and emotional state of other individuals (Davis, 1980; Mehrabian & Epstein, 1972).

One of the instruments for measuring empathy is the Interpersonal Reactivity Index (IRI; Davis, 1980), which has four subscales, fantasy, perspective taking, empathic concern and personal distress.

Using an aesthetic experience, Gernot, Pelowski and Leder (2018) studied the relation between empathy (emotion contagion) and EDA. Emotion contagion is "the ability to pick up and mirror", or in short to ‘‘feel into’’ emotions (p. 1). They showed abstract and representational artworks to 53 participants who were previously ranked low or high in emotion contagion. Participants were asked to rate the artworks by grades of liking, moving, interesting and valence dimensions using a seven-point Likert scale. Findings showed that individuals ranked high in emotion contagion had also higher EDA compared to individuals low in emotion contagion.

Anxiety and depression. Anxiety and depression are two major feelings that are commonly experienced by human beings. In his review on the neuropsychology of anxiety, Gray (1982) highlighted the role of the limbic system, more specifically the hippocampus. The limbic system (explicitly the amygdala) seems also to be involved in depression (Herman, Ostrander, Mueller & Figueiredo, 2005). These neuronal structures, similarly, to eccrine glands, are under the effect of the SNS. Reduction in SNS activity is commonly seen in patients with anxiety and depression disorders (Jarrett et al., 2003).

For measuring anxiety and depression two questionnaires are commonly used. Generalized anxiety disorder (GAD-7) is a self-report questionnaire with seven questions related to the state of anxiety in the previous two weeks. Patient health questionnaire (PHQ-9) is a self-report measurement with 9 questions about feelings of depression in the previous two weeks.

Confirming the reduction of SNS activity in anxiety and depression, some studies reported that anxious individuals have lower EDA (Vahey & Becerra, 2015). Naveteur and Baque (1987) showed neutral (landscape) or unpleasant (insects, bloody faces, etc) pictures to low and high anxious individuals. EDA was measured during the task, revealing that individuals with higher anxiety had lower SCL compared to non-anxious individuals. Regarding depression and EDA, some studies showed that patients with depression had lower EDA changes (Vahey & Becerra, 2015). In a study on the effect of depression on the emotional response of Spanish-speaking latins (Tsai, Pole, Levenson & Muñoz, 2003), EDA was measured while sad and amusing film clips were showed to depressed and non-depressed participants. Results indicated that depressed participants showed decreased EDA while seeing the film clips, in comparison with non-depressed participants.

1.4. Study aims and hypotheses

As our body reacts to cognitive and emotional stimuli, in this case writing about traumas, we decided that it is useful to measure physiological changes during the writing process. To the best of our knowledge, few studies had measured EDA changes in writing, especially in expressive writing, (see McGuire, Greenberg & Gevirts, 2005; Petrie et al., 1995) and there is a need to improve the understanding of cognitive and emotional processes involved in writing. To fill this gap in the literature, we designed a real-time study of expressive writing in which participants were randomly assigned to one of two groups: a control group writing about daily routines and an expressive group writing about a traumatic experience. We examined SCL before, during and after the expressive writing tasks, along with individual differences.

As our first hypothesis, we expected participants in both groups to show increased skin conductance level (SCL) when starting the writing task, as a result of SNS activation. As our second hypothesis, we expected a reduction in SCL after finishing the task, as a result of the recovery effect; the expressive group should have higher SCL than the control group, as a result of the request to recall a traumatic event. Our third hypothesis, according to studies reviewed previously, was that participants with high extroversion, anxiety and depression would show lower SCL, and participants with high neuroticism and empathy are likely to exhibit higher SCL during the writing task, especially among the expressive writing group.

2.Method

2.1. Participants

Fifty-seven first-year psychology students (9 males; *M* = 20.04, SD = 5.56; range = 17-51) from two classes in the University of Porto, Portugal, participated in this study in exchange for course credits. All of the participants were native Portuguese speakers. They signed an informed written consent form, filled in questionnaires in a classroom session and were informed about a forthcoming individual lab session. Participants were randomly assigned to a control (*n* = 28; range = 18-39 years, *M* = 19.89, SD = 4.54; 5 male) or expressive group (*n* = 29; range = 17-51 years, *M* = 20.10, SD = 6.50; 4 male).

2.2. Material

2.2.1. Psychophysiological measurement

EDA. Skin conductance level was collected via disposable electrodes (EL507 Biopac) and isotonic gel (GEL101). As it was shown in Figure 1.1 on different electrode placements for recording EDA, in this study data was collected from the volar surface of medial phalanges #2. Data was gathered with the Bionomadix BN-PPGED-T amplifier, together with the BN-LOGGER, from Biopac (Biopac Systems, Goleta, CA). with a high pass filter of 0.5-35Hz and a sampling rate of 1000 Hz. Skin conductance was measured in microsiemens (μs). Besides EDA data, ECG was also collected in this study but is not reported here (see Jacques, Alves, Fadaei & Barbosa, 2020).

SCL data was cleaned and analyzed with AcqKnowledge 5.0.2 software. Data was separated into five-minute parts; baseline (B; to measure NS-SCR for individual differences and physical changes in each participant; see Dawson, Schell & Filion, 2007), three segments of writing (W1, W2, W3) and post writing (PW).

2.2.2. Questionnaires

EPQ-R. The Eysenck Personality Questionnaire-revised (EPQ-R) is a self-report questionnaire with 100 yes/no items covering three dimensions of personality: extroversion (E), neuroticism (N), psychoticism (P) and L, which it refers to Lie/social desirability (Eysenck, 1991). In this study the Portuguese version of this questionnaire was used (Almiro, & Simões, 2014) with 70 items: neuroticism (23 items); extroversion (20 items); psychoticism (9 items) and lie/social (18 items). Cronbach's alpha and the scoring range for each subscale is: E, α = 0.83, 0-20; N, α = 0.87, 0-23; P, α = 0.55, 0-9; and L, α = 0.78, 0-18.

IRI. The Interpersonal Reactivity Index (Davis, 1980) is an empathy questionnaire with 28 items divided by four sub-scales, each with 7 items on a 5-point Likert scale, ranging from 0 = *does not describe me well* to 4 = *describes me very well*. Fantasy; the ability to empathize with fictional characters of books, movies or plays. Perspective-taking; measures cognitive empathy in the real world through adopting the point of view or perspective of others. Empathic concern; refers to the tendency to experience feelings of warmth, compassion and concern for others who are experiencing negative emotions. Personal distress; evaluate self-discomfort and anxiety when witnessing others having negative experiences. For this study we used the Portuguese version from Limpo, Alves and Castro (2010) with 24 items; 6 items for each subscale and scoring from 0 to 24. Scales are internally consistent (fantasy: α = 0.84; perspective taking: α = 0.73; empathic concern: α = 0.76 and personal distress: α = 0.80).

GAD-7. Assessing Generalized Anxiety Disorder is a self-report questionnaire related to the state of anxiety in the previous two weeks. This consisted of seven questions on a 4-point Likert scale, ranging from 0 = *not at all* to 3 = *nearly every day*. The scoring range is from 0 to 21 (Spitzer, Kroenke, Williams & Löwe, 2006). For this study the validated Portuguese version was used (Sousa et al., 2015) which has a high reliability and a Cronbach's alpha close to the original validation version of 0.88.

PHQ-9. The Patient Health Questionnaire (PHQ-9) is a short self-report of depression. Participants responded according to the previous two weeks, ranking how much these symptoms had bothered them on a 4-point Likert scale from 0 (*not at all*) to 3 (*nearly every day*). The scoring range is from 0 to 27. For this study we used the validated version for the Portuguese population with Cronbach's alpha similar to the original validation study (Kroenke, Spitzer & Wolliams, 2001) of 0.86 and a test-retest reliability of 0.87 (Torres, Monteiro, Pereira & Albuquerque, 2016).

PANAS. The positive and negative affect schedule (PANAS*;* Watson, Clark & Tellegan, 1988) is a short self-reported scale with 20 items about feelings; 10 items for positive affect (PA) and 10 items for negative affect (NA). High positive affect reflects feelings like enthusiasm, being active and pleasurable engagement, while low positive affect is characterized by sadness. High negative affect reflects feelings like unpleasant engagements, anger and disgust, and low negative affect reflects calmness. Participants rated their feelings before and after the task on a 5-point Likert scale (1 = *not at all to* 5 = *very much*). In this study the Portuguese version of this scale was used (Galinha & Pais-Ribeiro, 2005) with a Cronbach's alpha reliability of $\alpha = 0.86$ for PA and $\alpha = 0.89$ for NA. The scoring range for positive and negative affect varies from 10 to 50.

2.3. Procedure

Participants completed questionnaires in a collective classroom session. Data collection for the writing task and psychophysiological measurements were done in a laboratory setting during an individual one-hour session. After participants entered the room an experimenter fitted the EDA electrodes on their volar surface of medial phalanges of the two first fingers from the non-dominant hand. Participants received information about the study (Appendix A), signed an informed consent (Appendix B) and completed the PANAS scale. Instructions for the writing tasks were derived from Pennebaker and Beall (1986) study on expressive writing. The participants were given the instruction in a close envelope, and the experimenters were blind to these instructions. Participants were randomly assigned to one of two groups:

Control group: asked to think and write about their daily routine from the moment they wake up till the time they go to sleep as objectively as possible (Appendix C).
Expressive writing group: asked to think and write about the most traumatic experience in their life. They were asked to write about their thoughts and feelings (Appendix D).

Participants were asked to relax for 10 minutes (baseline), write for 15 minutes (writing task) and relax for 5 minutes after writing (post-writing) and answered the PANAS again.

All participants were debriefed and thanked at the end of the experiment. The whole experiment lasted about 30 minutes.

3.Results

Control (*n* = 28) and expressive groups (*n* = 29) wrote about daily routine or their most traumatic experience, respectively. Both groups were compared on PANAS scores, writing topic (daily routine vs. most traumatic experience), skin conductance level, EPQ-R, IRI, GAD-7, and PHQ-9. For the manipulation check, pre and post-writing PANAS scores were analyzed for both groups using mixed analyses of variance (ANOVA) with an alpha threshold set at .05. To examine the first and the second hypothesis on the impact of writing and its topic on SCL, a mixed design ANOVA was conducted, with *time* (B, W1, W2, W3 and PW) as within-subjects factor and *group* (control or expressive) as between-subjects factor. To examine the third hypothesis on the effect of individual differences on SCL changes, Mann-Whitney non-parametric tests were performed, with individual differences (EPQ-R, IRI, GAD-7, PHQ-9) as grouping variable and SCL as test variable. Correlations among individual differences and SCL were computed using Pearson correlation. Outliers were identified through boxplot analysis with interquartile range of 1.5, and missing values were given to the outlier variables. To reduce the type I error associated with multiple comparisons (see Holm, 1979), Bonferroni post hoc correction was used. In all comparisons, significant differences remained significant after using the Bonferroni correction with an alpha level of .005.

3.1. Manipulation check

To test that the experimental manipulation had the intended impact on the participants' mood we conducted a mixed ANOVA on pre and post-writing PANAS scores (see Table 1 for descriptive statistics), with time (pre-writing vs. post-writing) as within-subjects factor and group (control vs. expressive) as between-subjects factor.

Table 1

Descriptive statistics of PANAS

	Control		Expressive	
PANAS	*M*	SD	*M*	SD
Positive affect-B	25.61	5.971	26.24	7.415
Positive affect-PW	28.86	6.604	22.76	8.798
Negative affect-B	13.71	3.630	13.76	3.622
Negative affect-PW	11.25	1.647	21.72	9.130

Note. B = baseline; PW= post writing

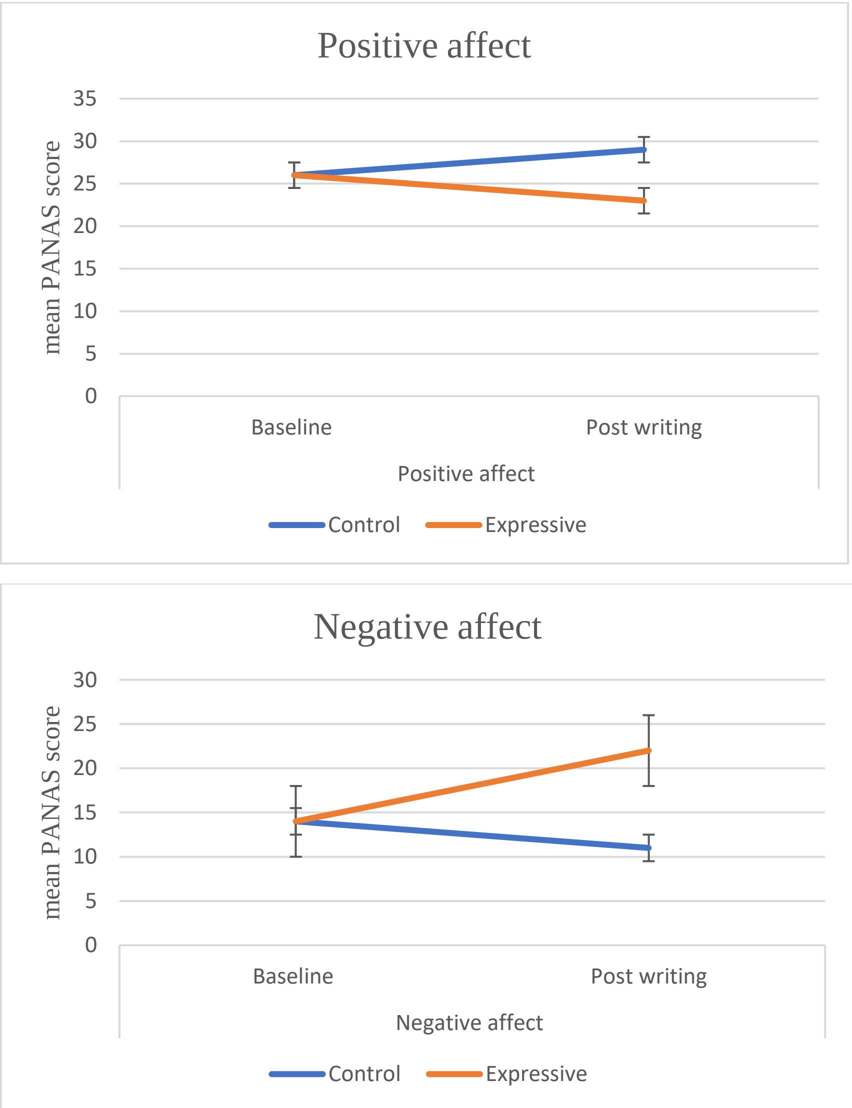
n (Control) = 28; *n* (Expressive) = 29

Mauchly's test indicated that the assumption of sphericity was violated both for positive affect and negative affect ($\chi 2(.00) = 0$, $p < .001$). Therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = 1$).

The main interaction of Time × Group was significant both for positive affect (PA); $F(1, 55) = 14.87$, $p < .000$, $\eta_p^2 = .213$, and for negative affect (NA); $F(1, 55) = 34.121$, $p < .000$, $\eta_p^2 = .383$. After writing the control group showed increased positive affect and the expressive group showed increased negative affect. The main effect of time was not significant for positive affect; $F(1, 55) = .018$, $p > .05$, but it was significant for negative affect; $F(1, 55) = 9.5$, $p < .003$. The main effect of group was not significant for positive affect, $F(1, 55) = 2.514$, $p > .05$, but it was significant for negative affect, $F(1, 55) = 23.041$, $p < .003$. Results showed that writing about daily routine increased positive mood (3.25 points average gain in PA), whereas writing about traumas and emotional experiences increased negative mood (7.96 points average gain in NA, see Figure .31).

Figure 3.1

Average of pre and post-writing positive and negative affect for both groups with standard error bars



3.2. Impact of writing topic on EDA

Changes in EDA throughout the writing assignment were analyzed by conducting 5 × 2 mixed ANOVA with SC (B; W1; W2; W3; PW) as within-subjects factor and group (control or expressive) as between-subject's factors, see Table 2 for descriptive statistics.

Table 2

Descriptive statistics of EDA in different moments

	Both groups					Control					Expressive				
Time	*n*	*M*	SD	min	max	*n*	*M*	SD	min	max	*n*	*M*	SD	min	max
B	56	8.36	4.36	0.98	2.80	27	8.2	4.78	0.98	19.16	29	8.51	4.01	3.22	2.8
W1	56	9.15	4.19	1.27	19.49	27	8.67	4.21	1.27	17.39	29	9.59	4.19	3.32	19.49
W2	54	8.04	4.08	1.11	18.66	27	8.02	4.37	1.11	18.66	27	8.05	3.85	1.51	16.28
W3	56	8.62	4.85	0.93	21.89	27	8.23	4.58	0.93	17.75	29	8.99	5.13	1.06	21.89
PW	56	9.81	4.56	1.07	21.18	27	9.5	4.62	1.07	19.41	29	10.1	4.56	2.24	21.18

Note. EDA was measured in microsiemens

Mauchly's test indicated that the assumption of sphericity was violated ($\chi 2(53.34) = 9$, $p < .001$). Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .074$). Analysis revealed no statistically significant interaction between Time × Group, $F(4, 54) = .754$, $p > .05$, nor main effect of group, $F(1, 54) = .000$, $p = .983$. Results revealed that the writing topic does not affect SCL. However, there was a significant main effect of time, $F(4, 208) = 19.84$, $p < .001$ revealing that SCL changed across time.

Table 3 shows the results of pairwise comparison between time (from baseline to post-writing) and SCL.

Table 3

Pairwise comparison of SCL from baseline till post-writing

Time (i)	Time (j)	Mean differences (i-j)	Sig.
B	W1	-.746*	.004
	W2	.065	1.000
	W3	-.061	1.000
	PW	-1.298*	.000
W1	B	.746*	.004
	W2	.811*	.000
	W3	.684*	.007
	PW	-.552*	.056
W2	B	-.065	1.000
	W1	-.811*	.000
	W3	-.127	1.000
	PW	-1.363*	.000
W3	B	.061	1.000
	W1	-.684*	.007
	W2	.127	1.000
	PW	-1.236*	.000
PW	B	1.298*	.000
	W1	.552*	.056
	W2	1.363*	.000
	W3	1.236*	.000

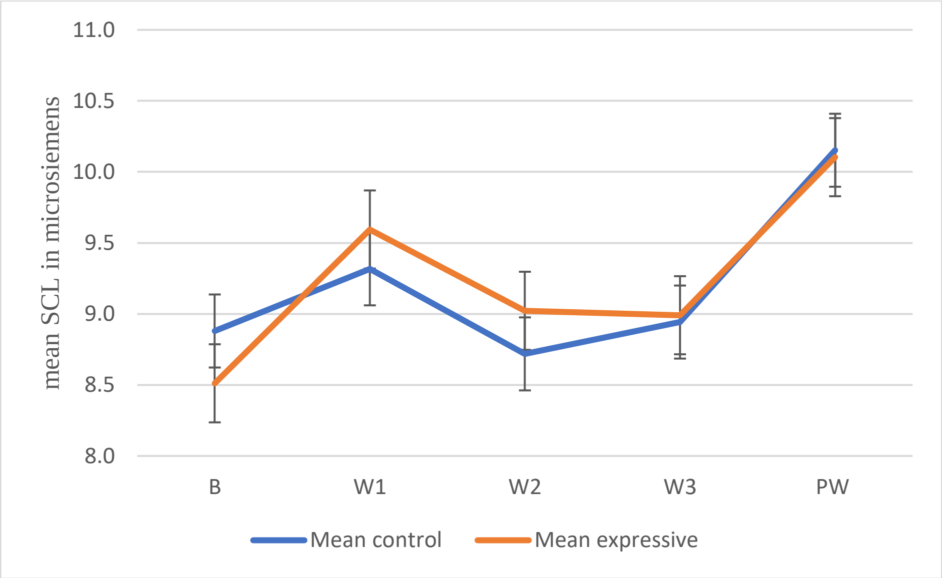
Note. SCL was measured in microsiemens

* The mean difference is significant at the .005

As is shown in Table 3, there is an increase in SCL from baseline to W1, with mean difference of .746 μs. There is a significant decrease from W1 to W2 with mean difference of .811 μs. Between W2 and W3, SC remained stable with no significant difference compared to the baseline, revealing that SCL in the baseline is similar to W2 and W3. Whereas from W3 to post-writing, there is a significant increase, with a mean difference of 1.23 μs. Results revealed that SCL increased upon starting the writing task, decreased after five minutes of writing, remained stable during the writing and increased significantly on finishing the task. Figure 3.2 displays SCL changes before, during and after the writing task for both groups.

Figure 3.2

SCL average from baseline to post-writing with standard error bars in control and expressive groups



3.3. Individual differences impact on EDA

Analysis on the impact of the writing topic on EDA showed that SCL was similar in both groups (control and expressive) during the baseline, writing task and post writing.

The writing topic caused no significant changes on SCL. Since there were no significant differences between control and expressive groups, the rest of the analyses about the impact of individual differences on skin conductance level were run for the whole sample.

3.3.1. Comparing individual differences and EDA. Table 4 exhibits mean and standard deviation of EPQ-R, IRI, GAD-7 and PHQ-9.

Table 4

Descriptive statistics for individual differences

Scale	Both groups					Control					Expressive				
	n	*M*	SD	min	max	*n*	*M*	SD	min	max	*n*	*M*	SD	min	max
EPQ-R-Extroversion	57	11.21	4.927	19	19	28	11	4.71	4	19	29	11.41	5.2	0	18
EPQ-R-Neuroticism	56	13.34	5.465	23	23	28	12.61	5.13	1	22	28	14.07	5.77	2	23
EPQ-R-Psychoticism	54	0.37	0.681	2	2	28	0.32	0.72	0	2	26	0.42	0.64	0	2
EPQ-R-Lie\social	57	7.67	4.311	18	18	28	7.93	4.65	0	18	29	7.41	4.02	0	15
IRI-Perspective taking	57	18.42	3.873	24	24	28	19.32	2.93	14	24	29	17.55	4.48	8	24
IRI-Empathic concern	57	18.68	4.218	24	24	28	18.43	3.51	10	24	29	18.93	4.85	7	24
IRI-Personal discomfort	57	1.86	4.681	20	20	28	1.5	3.69	4	18	29	11.21	5.51	1	20
IRI-Fantasy	57	17.12	5.134	24	24	28	15.79	4.68	9	24	29	18.41	5.29	6	24
GAD-7	57	8.67	5.661	21	21	28	8.18	5.41	0	21	29	9.14	5.94	0	21
PHQ-9	54	7.28	3.892	18	18	28	7.07	3.4	0	15	26	7.5	4.41	1	18

Individual differences and SCL were compared with the non-parametric test of Mann-Whitney. Results of the questionnaires were divided in quartiles (P25 and P75) and participants were grouped in low and high accordingly. Results showed no statistically significant differences between SCL and subscales of EPQ-R, IRI, GAD-7 and PHQ-9 during the writing task, except in the extroversion subscale of EPQ-R. Results suggest that there was a significant difference in SCL ($U = 65$, $p = 0.03$) between introverts and extroverts, with introverts higher and extroverts lower

3.3.2. Correlations. Pearson correlations were conducted for scales of individual differences (EPQ-R, IRI, GAD-7 and PHQ-9) and writing times (see Table 5). Besides the correlation within the scales (e.g., psychoticism and neuroticism subscales in EPQ-R; PHQ-9 and GAD-7), there is a significantly negative correlation between extroversion and SCL starting from the W2 moment. Findings suggest that five minutes after starting the writing task, extroverts and introverts showed different patterns in SCL, with extroverts measuring lower and introverts higher. This is in line with the findings of the non-parametric analysis. There was no significant correlation between other individual differences and SCL.

Table 5

Correlations between individual differences scales and SCL means

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.EPQ-R_Extroversion	—														
2.EPQ-R_Neuroticism	-.146	—													
3.EPQ-R_Psychoticism	-.127	.380**	—												
4.EPQ-R_Lie\Social	-.046	-.183	-.294*	—											
5.IRI_Prespective Taking	.063	-.207	-.358**	.542**	—										
6.IRI_Emapathic concern	.286*	.425**	-.286*	.271*	.317*	—									
7.IRI_Personal disconfort	-.199	.384**	.076	-.051	-.248	.196	—								
8.IRI_Fantasy	.029	.363**	.067	-.125	.090	.342**	.126	—							
9.GAD-7	-.204	.672**	.297*	-.188	-.034	.286*	.227	.204	—						
10.PHQ-9	-.042	.632**	.241	-.354**	-.079	.291*	.031	.288*	.746**	—					
11.SC_B	-.160	.085	.071	-.026	-.024	-.105	.098	-.035	.132	-.028	—				
12.SC_W1	-.210	.046	.067	.005	-.097	-.145	.080	-.077	.160	-.038	.933**	—			
13.SC_W2	-.310*	.241	.116	-.078	-.125	-.043	.157	.081	.244	.067	.932**	.966**	—		
14.SC_W3	-.341*	.069	.199	-.040	-.166	-.229	.066	-.155	.189	-.004	.876**	.937**	.980**	—	
15.SC_PW	-.353**	.048	.127	-.013	-.071	-.211	.043	-.174	.216	.009	.883**	.937**	.944**	.973**	—

*p < 0.01. **p < 0.05

4.1. Discussion

We studied a real-time writing task to explore the effects of writing topic (control vs. expressive) and individual differences on SNS activation by measuring SCL throughout the writing task. We expected a raise in skin conductance level (SCL) at the start of the writing, as a result of SNS activation, and a return to baseline upon writing task completion in both groups. Furthermore, we hypothesized the expressive group to exhibit higher SCL as a consequence of the request to recall a traumatic event. Finally, in accord with studies reviewed in the introduction, we expected that participants high in extroversion, anxiety and depression to show lower SCL, and participants high in neuroticism and empathy to exhibit higher SCL during the writing task, especially in the expressive group.

The most important finding is that SNS activation, in this case SCL, is influenced by the act of writing itself, regardless of the writing topic (control or expressive). SCL in both groups increased at the start of the writing task and increased again upon finishing it. Also, higher extroversion individuals, due to the effect of habituation, showed lower SCL compared to the introverts five minutes after starting the writing task.

4.1.1 Manipulation check

As expected, results of the PANAS scores revealed that expressive writing increased negative feelings in the participants. This is in line with previous findings about the effect of expressive writing, that it has an immediate negative effect on mood (see McGuire, Greenberg & Gevirts, 2005; Pennebaker & Beall, 1986). It is shown that negative emotions reported by participants in the expressive group were influenced by the writing topic (writing about the most traumatic event). Thus, we can conclude that our study confirmed the expected impact of expressive writing on participant’s mood.

4.1.2. Writing impact on EDA

Our findings support the hypothesis that starting a writing task causes a raise in SCL in both groups. SCL was significantly higher in the first five minutes of the writing task compared to the baseline (.746 μs) in both control and expressive groups and, it had a decrease about .811μs, five minutes after starting the writing. This finding is similar to the one report by McGuire, Greenberg and Gevirtz (2005), in which skin conductance increased in both groups in the first half of the 15 minutes compared to the second half of the writing task. A related study by Petrie et al. (1995) found that skin conductance decreased in both the control and experimental groups on the second day of the writing task compare to the first day. Future studies may need to measure EDA changes during and after a writing task in consecutive days, to have a better understanding of the SNS activation throughout several repeated writing sessions.

We hypothesized that those in the expressive group would demonstrate higher SCL during the writing. Our findings did not support this hypothesis. Results showed that both groups demonstrated similar changes in SCL during and after the writing. Similarly, to the findings of McGuire, Greenberg and Gevirtz (2005), results suggest that the content of the writing task does not cause a significant change in SCL between the control and expressive groups.

Contrary to our expectation that SCL in both groups would decrease with a regression to the baseline after finishing the writing task, SCL rose about 1.23 μs in both groups five minutes after finishing the task. The effect of artifacts was rejected due to the standard methodology for collecting the data and the equipment used in this study. A possible reason for this finding could be related to reward-seeking due to task completion, which is known to cause a raise in SNS activation (Patterson, Ungerleider & Bandettini, 2002). As was mentioned in the introduction, ventromedial prefrontal cortex, amygdala and hippocampus are related to the EDA activation. These areas are connected to the reward and reward-seeking system of the brain, which causes anxiety in reward-seeking situations (Dawson et al., 2007; Dixon et al., 2013; Patterson, Ungerleider & Bandettini, 2002). Probably upon completing the task, the reward-seeking system of the brain activated and caused a raise in EDA.

As EDA does not indicate the direction of positive or negative activation of SNS (Raphelson 1957), the raise of SCL in post-writing may be caused by different reasons in the control and expressive groups; because of writing task completion in the control group and because of finishing the process of remembering traumas and negative feelings in the expressive group. Results of the manipulation check are in line with this hypothesis, with the expressive group showing higher negative affect.

Another alternative explanation for not finding a difference in SCL between the two groups is related to the electrode positions and sides of the body. As Picard, Fedor and Ayzenberg (2016) mentioned, the right amygdala will raise negative emotions and so it will cause more skin conductance in the right side of the body and left amygdala will raise positive emotions, which will affect the left side of the body. In our study there were just four left-handed participants on whom the electrodes were positioned on their right hand, and the rest of the participants had the electrodes on their left hand. Perhaps, if we had measured both the right and left hands, we would have different results. Future studies are required to measure both hands using the wristband EDA measurements (Poh, Swenson & Picard, 2010) during and after the expressive writing, as it might lead to important findings on the function of SNS and emotions on different sides of the body.

4.1.3. Individual differences impact on EDA

It was hypothesized that the participants high in extroversion, anxiety and depression would show lower EDA during the writing task. Our findings support the hypothesis that only individuals high in extroversion have lower EDA during writing. Previous studies found similar results in which extroverts had lower EDA compared to introverts (Buckingham, 2008; Smith, 1983; Zvi & Elaad, 2016).

A possible reason for the difference in EDA five minutes after starting the writing task is the different habituation patterns in extroverts and introverts. Habituation has a common effect on EDA after a repetitive stimulus, as participants become less responsive to a familiar stimulus (Dawson et al., 2007), and it has been verified in previous studies that introverts have slower habituation compared to extroverts (see LaRowe, Patrick, Curtin & Kline, 2006; Smith, 1983). In this study extrovert participants were more habituated to the task after five minutes of writing while introvert participants were not, and as a result the EDA of introverts was higher.

Some related studies showed contrary findings–that extroversion did not have any effect on habituation of a given stimulus (Blanch, Balada & Aluja, 2014; Coles, Gale & Kline, 1971). Future studies are advised to analyze the individual differences and habituation during writing, as it might lead to important findings in demonstration of individual differences in the act of writing.

Our findings did not support any correlations between anxiety or depression with EDA. This is in contrast with some previous findings showing that individuals high in anxiety and depression had lower EDA (see Naveteur and Baque, 1987; Vahey & Becerra, 2015). Although both EDA, depression and anxiety are under the effect of the limbic system–mostly the amygdala and hippocampus (see Herman, Ostrander, Mueller & Figueiredo, 2005)–a potential explanation for the results found in this study is that previous studies did not measure EDA during the act of writing. Also, our target group was healthy individuals, and it is possible that the SNS activation in individuals with anxiety or depression disorder is different than in healthy individuals. Future studies are required to measure EDA during a writing task in individuals with anxiety or depression disorder and healthy controls to have a better understanding of underlying mechanisms of writing and its connection with SNS.

Our findings did not support the hypothesis that participants high in neuroticism and empathy had higher EDA during the writing. Results showed no significant correlation between neuroticism and empathy with EDA. This was contrary to previous studies (Gernot, Pelowski and Leder 2018; Love, Sollmann, Niehl & Francis, 2018).

Most of the studies mentioned above (Blanch, Balada & Aluja, 2014; Coles, Gale & Kline, 1971; LaRowe et al., 2006; Love, Sollmann, Niehl & Francis, 2018) were about the effect of sound and visual stimuli on EDA or on individual differences and habituation. To the best of our knowledge very few studies (McGuire, Greenberg and Gevirtz, 2005; Petrie et al., 1995) were dedicated to writing (especially expressive writing), EDA, personality and habituation.

4.2. Limitations and future directions

As mentioned previously, one of our limitations was that we measured skin conductance from one side of the body, but for a better assessment of SNS activation, it is advisable to measure EDA from both right and left sides. Another limitation is that in this study the content of the texts were not mentioned in the analyses, looking at the linguistic content can reveal emotional expressions in the writing and can illuminate our understanding of the expressive writing on emotional state of the participants. Also, in this study only the SCL was measured, while it is advisable to measure both SCL and SCR to have a better perspective of tonic and phasic changes in EDA (Benedek, & Kaernbach, 2010).

Our finding in relation to the increase in EDA in post-writing seems to be a reliable result because we conducted a second study with the same design but, in which participants wrote in the third person and, the same EDA results in post-writing were found (Jacques, Alves, Fadaei & Barbosa, 2020). As our finding about the post-writing increase in EDA was not reported in previous studies related with expressive writing, future studies should measure EDA from both right and left sides of the body during and after completing different tasks (e.g., Rubik's cube, drawing and writing) to have a better understanding of cognitive, emotional and physical connection underlying SNS activation.

4.3. Conclusion

This study was designed to improve the understanding about the psychophysiological and emotional effects of writing by measuring SNS activation. For this, we measured EDA changes as a sign of SNS activation, in a real-time writing session. Fifty-seven participants were randomly assigned to a control (n = 28) or expressive (n = 29) group, writing either about daily routine or the most traumatic event in their lives. EDA was measured before, during and after writing. The effects of the writing topic, emotions and individual differences on skin conductance were studied. To the best of our knowledge few studies investigated expressive writing and skin conductance, and this can help advance our knowledge about writing and its influence on the body, in this case through SNS activation. It was found that the writing topic does not affect EDA differently neither in control nor the expressive group. EDA rose upon start and finishing the writing task in both groups. It is possible that reward-seeking caused the EDA raise after the task completion. This appears to be an important finding; as it has not been mentioned in previous studies on EDA and writing, and it might lead to a better understanding of how writing task completion is related to reward-seeking. In addition, it was found that extrovert personality has a negative correlation with EDA five minutes after the start of the writing task. Due to the effect of habituation, participants higher in extroversion had lower EDA compared to introverts. No correlation was found between EDA and other aspects of individual differences. This study contributed to the improvement of knowledge about the psychophysiological and emotional changes during writing. By measuring SNS activation during writing, important findings about reward-seeking and individual differences effect on the body were found. These findings are valuable, since they provide more insight about psychophysiological changes related to emotional states.

References

Acqknowledge (Version 5.0) [Computer software] Goleta, CA: Biopac Systems Co.

Almiro, P.A., & Simões, M.R. (2014). Questionário de personalidade de Eysenck –Forma revista (EPQ-R). In L.S. Almeida, M.R. Simões, & M.M. Gonçalves (Eds.), *Instrumentos e Contextos de Avaliação Psicológica–Vol. II* (pp.211-229). Coimbra: Edições Almedina.

Almiro, P. A., Moura, O., & Simões, M. R. (2016). Psychometric properties of the European Portuguese version of the Eysenck Personality Questionnaire—Revised (EPQ-R). *Personality and Individual Differences, 88*, 88-93. https://doi.org/10.1016/j.paid.2015.08.050

Buckingham, R. M. (2008). Extraversion and neuroticism: Investigation of resting electrodermal activity. *Australian Journal of Psychology*, *60*(3), 152-159. https://doi.org/10.1080/00049530701656265

Benedek, M., & Kaernbach, C. (2010). A continuous measure of phasic electrodermal activity. *Journal of Neuroscience Methods*, *190*(1), 80-91. https://doi.org/10.1016/j.jneumeth.2010.04.028

Besel, L. D., & Yuille, J. C. (2010). Individual differences in empathy: The role of facial expression recognition. *Personality and Individual Differences*, *49*(2), 107-112. doi: 10.1016/j.paid.2010.03.013

Blanch, A., Balada, F., & Aluja, A. (2014). Habituation in acoustic startle reflex: Individual differences in personality. *International Journal of Psychophysiology 91*(3), 232–239. https://doi.org/10.1016/j.ijpsycho.2014.01.001

Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology*, *49*(1), 1017-1034.

Coles, M. G., Gale, A., & Kline, P. (1971). Personality and habituation of the orienting reaction: Tonic and response measures of electrodermal activity. *Psychophysiology*, *8*(1), 54-63. doi: 10.1111/j.1469-8986. 1971.tb00436. x.

Crider, A. (1993). Electrodermal response lability-stability: Individual difference correlates. In *Progress in Electrodermal Research* (pp. 173-186). Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-2864-7_12

Critchley, H. D. (2002). Electrodermal responses: what happens in the brain. *The Neuroscientist*, *8*(2), 132-142. https://doi.org/10.1177/107385840200800209

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113. doi: 10.1037/0022-3514.44.1.113

Davis, M. H. (2018). *Empathy: A Social Psychological Approach*. Routledge. ISBN 13: 978-0-8133-3001-3 (pbk)

Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. *Handbook of Psychophysiology*, *2*, 200-223. ISBN 62634X

Dean, R. T., & Bailes, F. (2015). Using time series analysis to evaluate skin conductance during movement in piano improvisation. *Psychology of Music*, *43*(1), 3-23. Doi: 10.1177/0305735613489917

Dixon, M. J., MacLaren, V., Jarick, M., Fugelsang, J. A., & Harrigan, K. A. (2013). The frustrating effects of just missing the jackpot: Slot machine near-misses trigger large skin conductance responses, but no post-reinforcement pauses. *Journal of Gambling Studies*, *29*(4), 661-674. doi: 10.1007/s10899-012-9333-x

Eysenck, S. B., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences*, *6*(1), 21-29. https://doi.org/10.1016/0191-8869(85)90026-1

Eysenck, H. J. (1991). Dimensions of personality: 16, 5 or 3? Criteria for a taxonomic paradigm. *Personality and Individual Differences, 12*(8), 773–790. https://doi.org/10.1016/0191-8869(91)90144-Z

Fung, M. T., Raine, A., Loeber, R., Lynam, D. R., Steinhauer, S. R., Venables, P. H., & Stouthamer-Loeber, M. (2005). Reduced electrodermal activity in psychopathy-prone adolescents. *Journal of Abnormal Psychology, 114*(2), 187–196. https://doi.org/10.1037/0021-843X.114.2.187

Galinha, I. C., & Pais-Ribeiro, J. L. (2005). Contribuição para o estudo da versão portuguesa da Positive and Negative Affect Schedule (PANAS): II-Estudo psicométrico. *Análise Psicológica*, *23*(2), 219-227. ISSN 0870-8231

Geen, R. G. (1984). Preferred stimulation levels in introverts and extroverts: Effects on arousal and performance. *Journal of Personality and Social Psychology, 46*(6), 1303–1312. https://doi.org/10.1037/0022-3514.46.6.1303

Gernot, G., Pelowski, M., & Leder, H. (2018). Empathy, Einfühlung, and aesthetic experience: The effect of emotion contagion on appreciation of representational and abstract art using fEMG and SCR. *Cognitive Processing*, *19*(2), 147-165. https://doi.org/10.1007/s10339-017-0807-8.

Gray, J. A. (1982). The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system, New York: Oxford University.

Harris, J. R. (2011). Explaining individual differences in personality: why we need a modular theory. *The Evolution of Personality and Individual Differences*, 121-153. ISBN 978-0-19-537209-0

Herman, J. P., Ostrander, M. M., Mueller, N. K., & Figueiredo, H. (2005). Limbic system mechanisms of stress regulation: hypothalamo-pituitary-adrenocortical axis. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *29*(8), 1201-1213. https://doi.org/10.1016/j.pnpbp.2005.08.006

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, 65-70. doi: 10.2307/4615733

Jarrett, M. E., Burr, R. L., Cain, K. C., Hertig, V., Weisman, P., & Heitkemper, M. M. (2003). Anxiety and depression are related to autonomic nervous system function in women with irritable bowel syndrome. *Digestive Diseases and Sciences*, *48*(2), 386-394. https://doi.org/10.1023/A:1021904216312

Jacques, T., Alves, R. A., Fadaei, S., & Barbosa, F. (2020). Real-time psychophysiological and writing correlates of expressive writing. *Experimental Psychology*. Advance online publication. https://doi.org/10.1027/1618-3169/a000495

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606-613. doi : 10.1046/j.1525-1497.2001.016009606.x

LaRowe, S. D., Patrick, C. J., Curtin, J. J., & Kline, J. P. (2006). Personality correlates of startle habituation. *Biological Psychology*, *72*(3), 257-264. https://doi.org/10.1016/j.biopsycho.2005.11.008

Lepore, S. J. (1997). Expressive writing moderates the relation between intrusive thoughts and depressive symptoms. *Journal of Personality and Social Psychology*, *73*(5), 1030. https://doi.org/10.1037/0022-3514.73.5.1030

Lepore, S. J., Greenberg, M. A., Bruno, M., & Smyth, J. M. (2002). Expressive writing and health: Self-regulation of emotion-related experience, physiology, and behavior. In S. J. Lepore & J. M. Smyth (Eds.), *The Writing Cure: How Expressive Writing Promotes Health and Emotional Well-being* (p. 99–117). American Psychological Association. https://doi.org/10.1037/10451-005

Limpo, T., Alves, R. A., & Castro, S. L. (2010). Medir a empatia: Adaptação portuguesa do Índice de Reactividade Interpessoal. *Laboratório de Psicologia*, *8*, 171-184.

Love, J., Sollmann, L., Niehl, A., & Francis, A. L. (2018, November). Physiological orienting response, noise sensitivity, and annoyance from irrelevant background sound. In *Proceedings of Meetings on Acoustics 176ASA* (Vol. 35, No. 1, p. 040002). Acoustical Society of America. https://doi.org/10.1121/2.0000981

Mangina, C. A., & Beuzeron-Mangina, J. H. (1996). Direct electrical stimulation of specific human brain structures and bilateral electrodermal activity. *International Journal of Psychophysiology*, *22*(1-2), 1-8. https://doi.org/10.1016/0167-8760(96)00022-0

Mehrabian, A., & Epstein, N. (1972). A measure of emotional empathy. *Journal of Personality*, *40*(4), 525-543. https://doi.org/10.1111/j.1467-6494.1972.tb00078.x

McGuire, K. M. B., Greenberg, M. A., & Gevirtz, R. (2005). Autonomic effects of expressive writing in individuals with elevated blood pressure. *Journal of Health Psychology*, *10*(2), 197-209. https://doi.org/10.1177/1359105305049767

Naveteur, J., & Baque, E. F. I. (1987). Individual differences in electrodermal activity as a function of subjects' anxiety. *Personality and Individual Differences*, *8*(5), 615-626. https://doi.org/10.1016/0191-8869(87)90059-6

Neumann, E., & Blanton, R. (1970). The early history of electrodermal research. *Psychophysiology*, *6*(4), 453-475. https://doi.org/10.1111/j.1469-8986.1970.tb01755.x

Patterson II, J. C., Ungerleider, L. G., & Bandettini, P. A. (2002). Task-independent functional brain activity correlation with skin conductance changes: an fMRI study. *Neuroimage*, *17*(4), 1797-1806. https://doi.org/10.1006/nimg.2002.1306

Pennebaker, J. W., & Beall, S. K. (1986). Confronting a traumatic event: toward an understanding of inhibition and disease. *Journal of Abnormal Psychology*, *95*(3), 274-281. doi: 002I-843X/B6/W0.75

Pennebaker, J.W. & Chung, C. (2007). Expressive writing, emotional upheavals, and health.

Petrie, K. J., Booth, R. J., Pennebaker, J. W., Davison, K. P., & Thomas, M. G. (1995). Disclosure of trauma and immune response to a hepatitis B vaccination program. *Journal of Consulting and Clinical Psychology*, *63*(5), 787-792. doi:10.1037/0022-006X.63.5.787

Picard, R. W., Fedor, S., & Ayzenberg, Y. (2016). Multiple arousal theory and daily-life electrodermal activity asymmetry. *Emotion Review*, *8*(1), 62-75. https://doi.org/10.1177/1754073914565517

Poh, M. Z., Swenson, N. C., & Picard, R. W. (2010). A wearable sensor for unobtrusive, long-term assessment of electrodermal activity. *IEEE Transactions on Biomedical Engineering*, *57*(5), 1243-1252. doi**:** 10.1109/TBME.2009.2038487

Raphelson, A. C. (1957). The relationships among imaginative, direct verbal, and physiological measures of anxiety in an achievement situation. *The Journal of Abnormal and Social Psychology*, *54*(1), 13–18. https://doi.org/10.1037/h0041374

Shields, S. A., MacDowell, K. A., Fairchild, S. B., & Campbell, M. L. (1987). Is mediation of sweating cholinergic, adrenergic, or both? A comment on the literature. *Psychophysiology*, *24*(3), 312-319. https://doi.org/10.1111/j.1469-8986.1987.tb00301.x

Smith, B. D. (1983). Extraversion and electrodermal activity: Arousability and the Inverted-U. *Personality and Individual Differences*, *4*(4), 411-419. https://doi.org/10.1016/0191-8869(83)90007-7

Society for Psychophysiological Research Ad Hoc Committee on Electrodermal Measures, Boucsein, W., Fowles, D. C., Grimnes, S., Ben-Shakhar, G., Roth, W. T., ... & Filion, D. L. (2012). Publication recommendations for electrodermal measurements. *Psychophysiology*, *49*(8), 1017-1034. https://doi.org/10.1111/j.1469-8986.2012.01384.x

Sousa, T. V., Viveiros, V., Chai, M. V., Vicente, F. L., Jesus, G., Carnot, M. J., ... & Ferreira, P. L. (2015). Reliability and validity of the Portuguese version of the Generalized Anxiety Disorder (GAD-7) scale. *Health and Quality of Life Outcomes*, *13*(1), 50. https://doi.org/10.1186/s12955-015-0244-2

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine*, *166*(10), 1092-1097. doi:10.1001/archinte.166.10.1092

Torres, A., Monteiro, S., Pereira, A., & Albuquerque, E. (2016). Reliability and validity of the PHQ-9 in Portuguese women with breast cancer. *The European Proceedings of Social & Behavioural Sciences*., 411-423. http://dx.doi.org/10.15405/epsbs.2016.07.02.38

Tsai, J. L., Pole, N., Levenson, R. W., & Muñoz, R. F. (2003). The effects of depression on the emotional responses of Spanish-speaking Latinas. *Cultural Diversity and Ethnic Minority Psychology, 9*(1), 49–63. https://doi.org/10.1037/1099-9809.9.1.49

Vahey, R., & Becerra, R. (2015). Galvanic skin response in mood disorders: A critical review. *International Journal of Psychology and Psychological Therapy*, 15(2), 275-304.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063.

Wood, E. H., Jepson, A., & Stadler, R. (2018). Electrodermal activity measurement within a qualitative methodology: Exploring emotion in leisure experience. *International Journal of Contemporary Hospitality Management*, *30*(11), 3363-3385. doi: https://doi.org/10.1108/IJCHM-11-2017-0781

Wood, E. H., & Kenyon, A. J. (2018). Remembering together: The importance of shared emotional memory in event experiences. *Event Management*, *22*(2), 163-181. https://doi.org/10.3727/152599518X15173355843325

Zvi, L., & Elaad, E. (2016). Contributions of personality dimensions to spontaneous and deliberate information processing in the guilty actions test. *International Journal of Psychophysiology*, *110*, 18-26. https://doi.org/10.1016/j.ijpsycho.2016.10.003

Appendix

Appendix A – Information given to the participant

Informação para o participante

O projeto de investigação "Mind-Body Interactions in Writing (M-BW): Psychophysiological and Linguistic Synchronous Correlates of Expressive Writing" tem como principal objetivo obter uma maior compreensão da escrita expressiva focando-se nos seus correlatos psicofisiológicos e linguísticos durante a realização de uma tarefa de escrita. O projeto apresentado permitirá realizar uma exploração psicofisiológica durante a produção de um texto e do vocabulário utilizado durante a escrita. O estudo para o qual pedimos a sua colaboração está previsto no projeto M-BW, financiado pela Fundação BIAL (BIAL/A-10780), e tem como objetivo obter uma maior compreensão acerca da forma como a mente e o corpo interagem durante a escrita. Se depois da sua participação entender necessário qualquer esclarecimento adicional, pode utilizar este contacto: ralves@fpceup.up.pt

Vimos, por isso, solicitar a sua participação neste estudo, que envolverá:

1. Uma tarefa simples de escrita;
2. a recolha de dados psicofisiológicos através de medidas do ritmo cardíaco, respiração e condutância da pele. Todos os procedimentos utilizados nos vários momento de recolha de dados são seguros, não causam desconforto, nem implicam quaisquer riscos adicionais para o participante. No entanto, a sua participação é voluntária e pode ser interrompida a qualquer momento caso assim o entenda;
3. a gravação em tempo real daquilo que escrever, usando para o efeito uma caneta digital;
4. o facultar de dados sociodemográficos, do percurso académico, e o preenchimento de questionários em diferentes momentos do estudo. Todos os dados fornecidos são confidenciais, serão anonimizados e apenas utilizados para o objetivo do estudo, sendo que cada participante será identificado através de um código que lhe será atribuído

salvaguardando quaisquer questões de privacidade. Estamos disponíveis para esclarecer qualquer dúvida que possa surgir.

Appendix B – Informed Consent

Declaração de Consentimento Informado

Eu, ____, com o código ___________ , abaixo-assinado, compreendi a explicação que me foi fornecida, por escrito e verbalmente, da investigação que se está a realizar e para a qual é pedida a minha participação. Foi-me dada oportunidade de fazer as perguntas que julguei necessárias, e para todas obtive respostas satisfatórias.

Tomei conhecimento de que, de acordo com as recomendações da Declaração de Helsínquia, a informação que me foi prestada versou os objectivos, os métodos, os benefícios previstos, os riscos adicionais e o eventual desconforto. Compreendo que da minha participação não resultam riscos adicionais e que a devolução dos resultados será feita numa sessão pública no final do estudo e para a qual serei convidado. Além disso, foi-me afirmado que tenho o direito de decidir livremente aceitar ou recusar a todo o tempo a minha participação no estudo, sem que isso possa ter como efeito qualquer prejuízo na assistência que me é prestada. Foi-me dado todo o tempo de que necessitei para refletir sobre esta proposta de participação.

Nestas circunstâncias, decido livremente aceitar participar neste projeto de investigação, tal como me foi apresentado pelo investigador(a).

______________, ___ de ___________ de 20____

____

Appendix C – Control group writing task

Durante os próximos 15 minutos, gostaria que escrevesse sobre a sua rotina diária. Descreva com detalhe todas as ações que realiza habitualmente, desde o momento em que acorda até ao momento em que adormece. O mais importante na sua escrita, é que descreva o seu dia com a maior precisão e objetividade possível. Garantimos o anonimato e absoluta confidencialidade de tudo o que escrever. Não se preocupe em escrever um texto correto. Não se preocupe com os erros ortográficos, com a estrutura das frases ou com a gramática. A única regra importante é que a partir do momento que comece a escrever, continue a escrever até que seja avisado que o tempo terminou. Utilize a caneta e a folha que lhe serão entregues. [15 minutos]

Appendix D– Expressive writing task

Durante os próximos 15 minutos, gostaria que escrevesse sobre os pensamentos e sentimentos mais íntimos associados à experiência mais traumática de toda a sua vida. Enquanto escreve, gostaria que se deixasse ir e explorasse as suas emoções mais profundas e íntimas. Pode escrever sobre as suas relações com os outros, incluindo os seus pais, namorados, amigos ou familiares. Pode escrever sobre o seu passado, presente ou futuro, ou sobre quem foi, quem gostaria de ter sido ou sobre quem é atualmente. Garantimos o anonimato e absoluta confidencialidade de tudo o que escrever. Não se preocupe em escrever um texto correto. Não se preocupe com os erros ortográficos, com a estrutura das frases ou com a gramática. A única regra importante é que a partir do momento que comece a escrever, continue a escrever até que seja avisado que o tempo terminou. Utilize a caneta e a folha que lhe serão entregues. [15 minutos]