MIND-BODY INTERACTIONS IN WRITING (M-BW): PSYCHOPHYSIOLOGICAL AND LINGUISTIC SYNCHRONOUS CORRELATES OF EXPRESSIVE WRITING

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Project website: http://m-bw.up.pt/

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Aims

Over the last thirty years, a wealth of research has consistently shown that expressive writing triggers a considerable number of benefits on health and psychological well-being (Fratarolli, 2006). Despite the many healing effects, the mechanism through which expressive writing operates is still poorly understood. In the M-BW project, we proposed that mind-body interactions during writing, as revealed by the exploration of psychophysiological indexes and linguistic markers, might prove instructive to understand how expressive writing leads to benefits. The studies conducted during the M-BW project explored handwriting, language use, electrodermal activity (EDA) and electrocardiographic (ECG) correlates, while the mind is engaged in an expressive writing task. Expressive writing is a particular form of writing in which a person narrates a personal deeply charged emotional event (Pennebaker & Beall, 1986). Adopting the basic expressive writing paradigm developed by Pennebaker and Beall (1986), we planned and conducted two complementary intervention studies. Those studies focused on the psychophysiological and linguistic synchronous correlates of expressive writing across two experimental conditions (writing about a personal traumatic event, or daily routine), but with an important distinction between them. While in the first study, participants wrote their texts using first singular person (I), in the second study, they wrote using third person singular (He/She). This manipulation of linguistic perspective coupled with synchronous psychophysiological exploration has hardly been studied in previous expressive writing studies and we believe it has provided some insights onto understanding how the mind and body interact during writing. The M-BW project also allowed for important developments to the HandSpy software, specifically a major update was the coupling of information on the handwritten trace with data from synchronous psychophysiological signals collected during expressive writing. Another critical goal achieved in the current project was the integration of the Emotaix.pt database within HandSpy. This allows for ease of access and user-friendly automated analyses of texts uploaded into HandSpy. An innovative aspect from the current project was the analysis of online psychophysiological markers while the mind is engaged in expressive writing. Such analysis provided clues into what seems to be contributing to the well-established healing effects of expressive writing, specifically expressive writing appears to be an important opportunity for emotion regulation.

Real-time writing measures

The writing measures used in both studies (language bursts and pauses), helped illuminate how the translation processes of expressive writing unfold in real-time. Alves,

Castro, de Sousa and Strömqvist (2007) defined a burst as an instance of activity between two consecutive pauses in which at least one word is written. Regarding pauses, one explanation for their function is that pauses are due to the competition for limited capacity (Just & Carpenter, 1992). Pause duration, another measure used in the study alludes to different cognitive processes (Alves, et al., 2008), with pauses longer that 2 seconds being reflective of planning and revising (Alves et al., 2008). Furthermore, Fayol (1999) proposed that when writers encounter difficulties brought on by the demands of the task, they adjust their writing speed by decreasing transcription time and/or increasing pause duration. Finally, writing fluency has been used to study writing processes (Leijten & Van Waes, 2013), as a marker of how demanding a task is for the writer (Olive, Kellogg & Piolat, 2001).

Linguistic markers

Previous literature has highlighted the difference between writing styles, in particular, the use of function and content words. Function words serve as the glue that holds content words together (Chung & Pennebaker, 2007). Function words include pronouns, prepositions, articles, conjunctions, and auxiliary verbs. Function words are automatic, making it difficult to control, therefore studying the use of function words has provided a way to explore social and personality processes (Chung & Pennebaker, 2007). Content words on the other hand are nouns, verbs, adjectives and adverbs. They convey the content of a communication. From a psychological perspective, function words reflect how people are communicating, whereas content words convey what they are saying (Tausczik & Pennebaker, 2010).

Psychophysiology

Electrodermal activity (EDA) has been one of the most widely used response systems in the history of psychophysiology. EDA is the response system of choice for the study of the sympathetic nervous system, since the neural control of the sweat glands is entirely under sympathetic control. Therefore, increases in EDA are due to increased sympathetic activation (Dawson et al., 2007). To get a broader picture of both sympathetic and parasympathetic activity, the electrocardiogram (ECG) is a common measure. From the recorded ECG the heart rate variability (HRV) for a given period can be calculated (Camm et al., 1996). Some widely-used HRV are time domain methods, such as SDNN, referring to the standard deviation of N-N intervals, reflecting overall HRV; the square root of MSSD (RMSSD), representing parasympathetic influences in heart-rate (Camm et al., 1996), and finally the LF/HF ratio estimates the ratio between sympathetic and parasympathetic activation, and consequently sympathovagal balance (Camm et al.,

1996). It has been shown that higher HRV is linked with better emotion regulation (see Appelhans & Luecken, 2006; Kim et al., 2019).

Study 1

Method

All procedures for ethical treatment of human participants were followed and approval was granted from the Faculty of Psychology and Education Science's at the University of Porto Ethics Commission.

Participants and design: Participants were 57 psychology undergraduates, recruited and randomly assigned to one of two groups: the expressive group (n = 29; range = 17-51 years, M = 20.1, SD = 6.50; 16 % male) or the control group (n = 28; range = 18-39 years, M = 19.9, SD = 4.54; 21.7 % male). Students were surveyed for general demographics, native language, and known physical or mental health illnesses. **Procedure:** Data collection occurred in a laboratory setting during a single 45-min session and the participants were tested individually. Participants wrote in isolated individual booths, under conditions of rigorous anonymity. Project participation was discussed with every participant, and individual informed consent obtained for all. Participants were randomly assigned to each condition, and the experimenters were blind to the experimental conditions. Participants were then fitted with the psychophysiological equipment to record skin conductance level (SCL), heart-rate, and heart-rate variability, through ECG. To record EDA two electrodes were placed at the medial phalanges of the non-dominant hand. To record ECG, three electrodes were placed according to a lead III configuration. Participants wrote for 15-minutes using special microdotted paper and a smartpen. While the participants wrote, continuous record handwriting, EDA and ECG were recorded. Psychophysiological data was recorded from 10 minutes prior to writing to the 5 minutes after writing. All participants were thanked and debriefed at the end of the experiment.

Measures:

Psychophysiological data. Participant's physiological activity was assessed by collecting two measures: SCL and ECG; Raw EDA and ECG were recorded using, the Bionomadix BN-PPGED-T and BN-RSPEC-T amplifiers, respectively, together with the BN-LOGGER, all from Biopac (Biopac Systems, Goleta, CA). Signals were recorded at a sampling rate of 1000 Hz and filtered using a band pass of 0.5 –35 Hz. To clean and divide the raw EDA and ECG data we used Biopac Acqknowledge 5.0. Baseline was collected at rest to correct for the effects of the writing task on physiological activation. EDA data from two participants and ECG data from five participants were excluded from psychophysiological analysis due to artifacts.

Real-time writing measures. Participants wrote their texts using Neo smartpens M1 and microdotted paper sheets (Neo Smartpen Inc, Scotts Valley, CA). Text production was analyzed using HandSpy 2.3 software, to measure burst length, pause duration, number of pauses, fluency, and burst speed. Participants in the control group wrote about their daily routine, and participants in the expressive group wrote about the most traumatic experience of their life, in the first person singular. The expressive group followed the typical instruction of expressive writing paradigm, as follows: write about the most traumatic and upsetting experience that you have ever experienced in your life and describe in detail your deepest feelings and thoughts associated with that experience; The neutral topic asked participants to write about their daily routines, by describing in purely objective terms the actions performed in a typical day.

Linguistic word usage. The participants texts were analyzed on HandSpy 2.3 to check for linguistic word usage. The measures analyzed were number of characters and words used, average length, number of lemmas number of content words, number of function words, different content words, average content word length, number of different function words, average word length, average function word length, lexical density, base TTR, MTLD, HD-D, VOCD, and idea density.

Data and statistical analysis. The control and expressive group were compared on real-time writing measures, linguistic word usage, mean SCL and various HRV measures (HR, SDNN, RMSSD, LF/HF ratio). Outliers were identified through boxplot analysis and removed from the database. Group differences were tested using independent mixed-design ANOVA conducted for the writing and linguistic data, with *group* as between-subjects factor. Mixed-design ANCOVA were independently performed for EDA, heart rate and each ECG measure, with *group* as between-subjects factor, *time-period* as within-subjects factor, and *baseline* values of EDA and ECG as covariates.

HandSpy 2.3 & 2.4. At the very start of the project we switched smartpens' supplier from Livescribe to Neonotes. The later offered increased functionalities, particularly easier and more efficient data collection procedures, and a smoother cloud integration with the HandSpy server. HandSpy 2.4 featured a new method for automatic extraction of the writing samples uploaded into the HandSpy server, using google drive. Another major development to HandSpy was a module for text analysis of a text emotional content, which was done following the team's previous implementations of an emotional lexical database (viz. Emotaix.pt and Emospell), and psychophysiological integration. Implementation of these features took many months of coding. At the same

time several bugs in the platform were fixed, namely the ability to save analyzed protocols and to export the analyzed data as an excel file. HandSpy was the focus of a chapter in an edited book (Alves, Leal, & Limpo, 2019), with HandSpy 2.3 having been announced at the 1st Literacy Summit of the European Literacy Network (Jacques, 2018) and further presented in a research workshop at the University of Luxembourg (Jacques, Costa, Alves, Paiva & Leal, 2019).

Results

Regarding the real-time writing measures, participants in the expressive group paused for longer than the control group and were not significantly different in any other measure. For the linguistic analysis the expressive writing group wrote using a higher number of different function words, higher average word length, higher average function word length and lower lexical density. For the psychophysiological results, both groups showed higher SCL during and after the writing task. No significant differences were found for heart rate, SDNN and RMSSD. But the expressive group showed higher LF/HF ratio during and after writing, than the control group.

Study 2

Method

Participants and design: Participants were 57 psychology undergraduates, recruited and randomly assigned to one of two groups: the expressive group (n = 28; range = 18-26 years, M = 18.9, SD = .83; 10.7 % male) or the control group (n = 29; range = 18-53 years, M = 20.8, SD = 1.33; 20.7 % male). Students were surveyed for general demographics, native language, and known physical or mental health illnesses. **Procedure:** The procedure was identical to the described in study 1. **Measures**: All measures collected remained the same as the study 1, except for the instructions given to the participants. Participants in the control group wrote about their daily routine and participants in the expressive group wrote about the most traumatic experience of their life. Both groups wrote using the third person singular (He/She). The expressive group followed a modified version of the expressive writing instructions, as follows: write about the most traumatic and upsetting experience that you have ever experienced in your life and describe in detail your deepest feelings and thoughts associated with that experience, using third person pronouns; The neutral topic asked participants to write about their daily routines, by describing in purely objective terms the actions performed in a typical day, using third person pronouns.

Data and statistical analysis. The analytical procedure from study 1 was replicated on the same measures, collected in study 2.

HandSpy 3.0. A major result of this project was the development of HandSpy 3.0 software. A new version of HandSpy was developed, including major updates such as a redesigned user interface, improved analyses, and three main views for data examination and analyses: manuscript view (allowing for real time analyses), annotated view (print version of the collected sample, allowing for offline text analyses), and video playback of a protocol (showing text production in real time along with visualization of some relevant indexes). These developments of the HandSpy software were performed by a research assistant in Computer Science, JCP, supervised by JPL.

Results

A comprehensive analysis of the real-time writing measures, linguistic, and psychophysiological (SCL and ECG) correlates of expressive writing was conducted for the second study. For the writing analysis, no significant differences were found for any of the writing measures. The linguistic analysis showed that the expressive writing group used a higher number of different function words, higher average word length, and higher average function word length. No significant differences were found for lexical density. Psychophysiological results showed that both groups have higher SCL after writing, and heart rate was higher for the expressive group during and after writing.

Discussion

In the current project, we proposed that mind-body interactions during writing, as revealed by an exploration of psychophysiological indexes and linguistic markers, might be instructive to understand how expressive writing leads to its benefits. The studies conducted during the project, explored handwriting, vocabulary use, electrodermal activity (EDA) and heart activity through ECG, while the mind is engaged in an expressive writing task. Results presented here seem to provide further insight on how expressive writing operates. The studies conducted focused on the psychophysiological and linguistic synchronous correlates of expressive writing across two conditions (writing about a personal traumatic event vs. daily routine). In the first study, participants wrote their texts using first person singular, and in the second study, using the third person.

Regarding the real-time writing correlates of expressive writing, both studies had interesting results. In the first study the expressive group paused for longer. In the second study none of the real-time writing measures showed significant differences between groups. In other words, only participants who completed the traditional writing paradigm paused for longer during writing, in comparison to the control group. This is an interesting finding, since participants in this expressive group have to think about emotionally charged topics, with themselves as the “main character”. In adult writers, pause duration

is thought to increase when dealing with a secondary task (Fayol, 1999) or, cognitive overload (Alves, Castro, de Sousa, 2007), such as the emotional load that possibly comes with expressive writing. Under this light, our findings suggest that the traditional expressive task involves a higher cognitive load than writing about a daily routine.

In respect to the linguistic correlates of expressive writing, in both studies, the expressive group showed a higher number of different function words, higher average word length and higher function word length than the control groups. However only in the first study the expressive group showed lower lexical density. These results suggest that participants who completed expressive writing show a different writing style, regardless of perspective, using a higher number of different function words, which are known to be automatic, and difficult to control (Chung & Pennebaker, 2007). A previous study has shown than pronoun use (a type of function word) is higher after a traumatic event (Pennebaker & Lay, 2002), which is in accordance with the results in our study. Nonetheless, as far as we know this is the first study that evaluated measures such as word length, lexical density and idea density, thus adding novel findings to the field.

Finally, to study the psychophysiological correlates of expressive writing, we analyzed both SCL, heart-rate and HRV activation. Regarding SCL, both studies showed an increase in SCL for both groups, after writing. For the heart-rate and HRV, in the first study the expressive group showed significantly higher LF/HF ratio that the control group, suggesting that expressive writing increases sympathovagal balance. In the second study, HR was significantly higher in the expressive group, but no other measure yielded significant difference between groups. These results suggest that expressive writing is associated with increased activity of the sympathetic nervous system, with SCL increasing in all groups after writing. HRV results showed that expressive writing increased sympathovagal balance when writing in a first-person perspective, but increased HR when writing in the third person. This suggests that during traditional, first-person expressive writing, increased emotion regulation happening might be happening (Kim et al., 2019). Additionally, during third-person expressive writing increased activation of the sympathetic nervous system seems to be in place. These are important findings in the study of expressive writing as they suggest that there are specific writing, linguistic and psychophysiological correlates of expressive writing.

Conclusion

This study had as a main goal the better understanding of the mind-body interactions that occur during writing. With that goal in mind, two experimental studies were designed where participants wrote about either an emotionally charged topic or a

neutral topic. Real-time writing, linguistic and psychophysiological data were collected and analyzed to study the underlying processes of expressive writing in real-time. To our knowledge, the psychophysiological and linguistic synchronous correlates of expressive writing have not been studied before and they could provide important information about the healing effects of expressive writing. Findings from both studies suggest that there are particular correlates for expressive writing. In the first study, real-time writing measures showed that in comparison to the control group, the expressive group paused for longer, used a larger number of different, longer function words, and showed higher LF/HF ratio, during and after writing, suggesting higher sympathovagal balance. In the second study, the expressive group used a larger number of different, longer function words, and showed higher HR during and after writing, than the control group. These are important findings, as they seem a step forward in the study of expressive writing as a mechanism for emotion regulation. In addition to the main findings, another major outcome from these studies was the development of HandSpy 3.0, which is a valuable tool to further explore writing in real-time.

Recommendations

Future studies should take into consideration the following aspects. First, studies might choose to narrow the topic of disclosure, by selecting participants based on a previous traumatic event. The participants recruited in our studies were college students, who wrote on a wide range of topics, therefore, this heterogeneity of experiences could have led to diversity of writing and linguistic markers and perhaps in psychophysiological responses. Thus, it seems worth pursuing future experimental studies using the expressive writing paradigm on clinical samples.

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