Heart rate variability and level of personality functioning - a pilot study

Abstract

In the DSM-5 manual a new dimensional system for Personality Disorders was included in section III. We aimed to pave way for a biological validation of this dimensional system by measuring base line heart rate variability (HRV) in a group of patients vs controls already assessed with the Level of Personality Funciotning Scale (LPFS). HRV is a measure of vagal tone linked to emotional regulation and is previously shown to be a good but unspecific marker of psychiatric disease, inversely correlated with the severity of disease. We examined 9 participants of which 5 were patients and 4 controls. We found significantly lower HRV in patients vs. controls and a significant correlation between level of Emotion Regulation, a sub domain of Identity in the LPFS, and HRV, with a P-value of 0,031. That the overall LPFS was not significantly correlated with HRV (P=0,075) must be seen in light of the small amount of participants. Our results indicate a correlation, but a larger and better controlled study has to be conducted to validate the LPFS properly.

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Content

1.0 Introduction

Personality disorders (PD) are common and debilitating disorders associated with high levels of symptom distress, poor quality of life, and low occupational functioning . Social costs are substantial, due to high utilization of health resources and lost work capacity . Data from the United Kingdom demonstrates increased mortality rates; life expectancy at birth is shortened by 19 years for women and 18 years for men .

Research during the last decades has shown that patients with PD could benefit from comprehensive treatment programs . However, it appears that the severity of PD is more important for treatment planning and prognosis than PD type. In concordance with this, research has shown that PDs are dimensional phenomena, without clear boundaries between what is "normal" and what is "pathological" . During the preparation of the DSM-5, APA considered to replace the categorical PD system with a dimensional one. However, a few months before the publication of DSM-5, it was concluded that there was not enough empirical evidence for the validity and clinical utility of the proposed model. Thus, it was decided to include two PD diagnostic systems in DSM-5; the official one ("Section II"), which is identical to the former DSM-IV system, and a dimensional one, which is included furthest back in DSM-5 for further study ("Section III Alternative Model for PDs ", Section III-AMPD).

In Section III-AMPD, personality disorders are described by a moderate or greater impairment in personality functioning (criterion A) and the presence of at least one pathological personality trait (criterion B). Criterion A aims to capture "generalized severity of personality pathology" and includes five levels of impairment in personality functioning (i.e., Level of Personality Functioning Scale, LPFS), from little or no impairment (level 0) to extreme impairment (level 4). The LPFS comprises two main domains, i.e., self-pathology and interpersonal problems , and each main domain includes two subdomains, i.e., identity and self-direction (self domain), and empathy and intimacy (interpersonal domain).

In order to be diagnosed with a PD, a moderate impairment of personality functioning should be present (LPFS level 2). Besides, the patients should have one or more pathological personality traits as well (criterion B). The new model is in need of validation, also with a biological marker (7), for which Heart rate variability (HRV) is a good contender.

HRV is the beat to beat variation of heart rate, meaning that the length in time between consecutive heart beats is not constant, like it would be if the heart beat like a metronome, but fluctuates as time passes. This is most clearly seen as respiratory sinus arrhythmia (RSA), a phenomenon in which the heart beats faster during inspiration and slows down during expiration. HRV was first noticed to be of clinical importance in 1965 when two pediatricians became alert to the fact that decreased fluctuation of fetal CTG was a primary sign of fetal distress (14). Since then research has shown HRV to be influenced by sympathetic and parasympathetic activity (14). One theory is especially interesting with regard to emotional regulation and that is the Polyvagal Theory by Stephen Porges (15). In short Porges proposes that the vagus nerve consists of two physiologically separate parts: an umyelinated dorsal vagus and a myelinated ventral vagus; the dorsal one being phylogenetically older than the ventral. Porges argues further that the autonomic response of a mammal is three dimensional on scale of increasingly perceived threat: the ventral vagus is recruited first by down regulating HRV, the sympathetic nervous system second by increasing heart rate and activating the HPA-axis, and the unmyelinated dorsal vagus last by instigating a primitive freeze response giving bradycardia. The ventral vagus is also coupled to the trigeminal and facial nerve in the medulla oblongata; nerves that mediate facial expression, vocalization and listening, all important for social behaviour. This, if we are to follow Porges, means that when the ventral vagus up regulates HRV promoting growth and restoration by inhibiting the sympathetic nervous system and the HPA-axis (15) , centres of vocalization, listening and facial expression will also be stimulated, making HRV an interesting objective measure of social competence. HRV has indeed been proven to be a good, but unspecific indicator of psychopathology as the HRV of controls is shown to be significantly higher than that of patients with psychopathology (14,16). Furthermore, there seems to be an association between the severity of psychopathology and degree of HRV, i.e., patients with more severe disorders tend to have lower HRV. A recently published meta-analysis also shows that there is a negative correlation between resting state HRV and borderline personality disorder (17). Moreover they suggested that the lowered HRV in BPD patients may reflect a common psychophysiological mechanism concerning emotional regulation, which is represented in the LPFS under the Identity domain. Base line HRV should therefore qualify as a validator of

LPFS and it will be especially interesting to test the correlation between HRV and the difficulties in Identity and Emotion Regulation highlighted through the LPFS interview.

We use two domains for the measuring of HRV, the frequency domain and the time domain. In the frequency domain the *Fourier transform*, also called the *auto regression analysis*, is used to estimate the size of the integrals of different sinusoidal patterns, graphically reproduced as a spectrogram. For instance if one type of prominent heart rate variability is happening 12 times a minute we can see this on the spectrogram as a peak around the 0,2 Hz mark. The mean respiratory frequency in human adults lies around 12 times a minute and thus RSA can often bee seen as a peak around 0,2 Hz. The respiratory frequency (RF) does however vary considerably between healthy adults and will therefore manifest itself on the spectrogram in different ranges of Hz. (18). This can lead to problems regarding the analysis of the different frequencies. Take the interpretation of High frequency (HF, 0,15-0,40 Hz) domain for instance: while the RSA is most often included in this range it can also lie outside it, i.e. in the low frequency range (0,04-0,15 hz), this being the case for natural slow breathers who for example can reach RF no more than 6/min. By assuming RSA to be situated in the HF range you can, in rare instances, be lead to believe that a slow breather hardly has any RSA at all when in fact it is present in the LF range. RSA is thought to be a manifest of the myelinated vagus, while the LF is thought to be mostly of unmyelinated origin, keeping in mind the exception given above (18).

In the time domain the most useful measurement is the RMSSD, or the root of the mean squared successive differences of R-R-intervals. The RMSSD is measurement of global HRV, i.e. no sinusoidal patterns can be deducted from the RMSSD number. However it is believed that RMSSD, being a measure of beat to beat variance in heart rate, is a good measure of vagal tone, since the beat to beat variance is occurring too quickly to be of sympathetic origin (19).

Psychophysiological studies involving patients with PD use to focus on negative emotions. For instance, in a study including 9 patients with Borderline personality disorder and 11 controls, Austin et al. used an emotional paradigm by showing participants three videoclips of which two were considered highly emotionally provocative (showing fights between family members) and one was considered neutral (20). Austin et al found that the borderline patients showed different trajectories than controls for HRV and heart period during the viewing of these clips. Whereas the HRV rose for the controls it sunk for the borderline patients, and only for the controls was the correlation between the changes in heart period and HRV significant, which suggests that vagal mechanisms were responsible for the changes only in the control group. This study provides important insights in the functioning of the parasympaticus in borderline patients and how they cope with negative feelings. However, processing of positive emotions might be as important as processing of negative emotions . As far as we can see, there are no HRV studies focusing on positive emotions in PD patients.

According to Panksepp , positive emotions can be differentiated within three broad categories, i.e., PLAY, SEEKING, and CARE. Among these, PLAY is maybe the least explored in the PD field. In young childeren, this affect is obvious when they are playing and enjoying themselves. In adult people, PLAY is more subtle and complex and is involved when people are playing games, are joking, or watching amusing films. Moreover, PLAY, in form of humour, is an important aspect of psychotherapy, as made explicit in modern treatment approaches, for instance Mentalization Based Therapy (MBT). However, this aspect of play has hardly been explored in empirical research. The first step in approaching this issue scientifically is to examine patient characteristics. Measuring psychophysiological reactivity in response to amusing film clips is a good starting point.

CARE is another positive basic emotion that needs more exploration. It is involved when one feels closeness towards another person, want to help another person, or feels empathy or tenderness towards another person. As far as we can see, there are no studies in the PD field that has examined HRV using paradigms that may activate the CARE system.

2.0 Aims

This pilot study has two aims. We hypothesize that HRV is negatively correlated with LPFS, i.e. the lower the HRV, the higher the LPFS score. We expect this correlation to be most significant for for the empathy domain and for emotion regulation, which is a subdomain of the Identity domain.

Second, this project seeks to explore emotional reactivity with respect to positive affects. More specifically, it will explore the PLAY and CARE system by measuring HRV response towards a humoristic and tender film clip (12, 26) . The second aim is more explorative and we don’t have any specific hypotheses concerning the humoristic videoclip. However, we expect that patients with high levels on the interpersonal domain of LPFS, i.e., more problems with empathy and intimacy, will have reduced emotional reactions on the tenderness clip.

Overall, this pilot study aims at paving the way for larger studies on the association between HRV and LPFS, as well as on larger studies on positive emotions and HRV in the PD field.

3.0 Method

3.1 Participants

This project is a substudy of an ongoing study on the validity and clinical utility of the AMPD in DSM-5, i.e., the "Multicenter Study of the DSM-5 Alternative Model for Personality Disorders" (22). The participants ranged between 0 and 3 on LPFS. No patients with a score of 4 were recruited for this study, due to difficulties recruiting participants from a group with such serious level of personality pathology.

Patients in the HRV study were recruited from the Department of Personality Psychiatry. Controls were recruited from the student population at the University of Oslo.

The participants consisted of 5 patients and 4 controls of which 7 were female and 2 male, one male in the control group and one in the patients group. The BMI of the participants ranged between 19,0-27,1 with the mean of the patients being slightly higher at 22,6 compared to the control group at 20,5.

3.2 Assessment of personality functioning

Participants were interviewed using the LPFS interview: "Clinical Interview for the DSM-5 Alternative Model for Personality Disorders, Module 1" (SCID-AMPD-1), translated into Norwegian by the research group at the Department of Personality Psychiatry. Moreover, patients are assessed by the Mini International Neuropsychiatric Interview for symptom disorders (23) and the Structured Clinical Interview for Axis II disorders (SCID-II)[22] for personality disorders. Assessment is performed by clinicians/clinical researchers at the Department of Personality Psychiatry within the context of the Multicenter Study of the DSM-5 Alternative Model for Personality Disorders.

3.3 HRV assessment

ECG was measured using portable Biopac PM150 hardware and Ag/AgCl electrodes, placing the negative electrode on the right clavicula, the positive on the left 10th costa and the neutral on the 10th right costa. The hardware was connected to a portable computer containing acqknowledge software where the hardware data was graphically reproduced as a one lead ECG. In Acqknowledge we saved the raw data as a text file. HRV was analyzed, manually controlling every R-wave, using Artiifact 2.09.

The participants were first measured during a 7 min period of rest. After the resting condition, three videoclips were shown over a period of approx. 12 min. The first film clip is from the movie "Benny & Joon" in which Benny (Johnny Depp) plays the fool in a coffee shop. The participant then rested for 2 minutes, before a second clip, of neutral character from the movie "Blue" was shown. A 2 min vanilla task was then used as such a task is shown to have the potential to be more effective than a pure resting baseline (25). A third clip of tender character was then presented. The tender clip is from the movie "Forrest Gump", a scene in which the main character Forrest is introduced to his son for the first time. The clips can be downloaded at http://nemo.psp.ucl.ac.be/FilmStim/film.htm and are validated in Schaefer et al's paper: "*Assessing the effectiveness of a large database of emotion-eliciting films: A new tool for emotion researchers*" (26). Schematically the paradigm was as follows:

1. Emotional regulation capacity will be measured by HRV during rest (7 min).
2. Emotional reactivity HRV– An amusment-inducing film clip of approx. 2min will be presented. The film clip is validated for emotion induction on large samples (26).
3. Emotional recovery HRV second baseline – 2 min
4. Emotional reactivity HRV- A neutral film clip of approx. 40 sec will be presented.
5. Emotional recovery HRV vanilla task – 2 min
6. Emotional reactivity HRV - An emotional film clip of approx. 2 min will be presented. The film clip is validated for emotion induction on large samples (26).
7. Emotional recovery HRV third baseline - 2 min
8. The participants were given a questionnaire using a Likert scale from 0 (not funny or tender) to10 (very funny or tender) to assess how they emotionally reacted to the clips.

HRV assessment was performed at the Department of Personality Psychiatry at the OUS. It iwas done at the same day as the patients received treatment at the department before the consultation with the therapist. The controls were tested in one of the researcher's home.

3.4 Analysis, statistics and power

Artiifact 2.09 analyses the data in the time domain and the frequency domain. The main index of the time domain is the RMSSD. Concerning methods in the frequency domain, Artifact gives an estimate of HRV for three frequency registres, i.e., very low, low and high, as well as an overall estimate of HRV. We will assume that the RSA lies within the HF range, and HF will therefore be the frequency domain on which we will focus our analysis.

SPSS will be used to investigate the association between these HRV estimates and LPFS. As we will not have enough participants at each level, ANOVA statitistics will be used rather than correlation statistics. The study is too small to give significant results at the 0.05 level. However, it may give a foundation for a power analysis for a larger study on the association between HRV and LPFS.

4. Results

We will first present the results regarding the baseline measurements of HRV compared to global LPFS scores and the scores for the sub domains Identity, Self-direction, Empathy and Intimacy as well as the sub facet of Identity which deals with Emotional regulation. In table 1 one the unanalyzed data is presented for each and every participant, the HRV data being base line measurements. 1-5 are patients at the OUS. 6-9 are healthy controls.

Deltager	LPFS	RMSSD	HF	LF	Mean RR	Psych.Meds
1	3	23	73	70	643	-
2	1	23	188	129	853	+
3	2	51	819	1213	671	-
4	2	31	1077	379	833	+
5	2	24	211	450	624	-
6	0	59	1766	1861	960	-
7	1	43	1443	727	874	-
8	0	42	753	54	938	-
9	0	62	1261	194	898	-

Table 1.

Correlations

		HF	RMSSD
HF	Pearson Correlation	1	1
	Sig. (2-tailed)		
	N	9	9

Identity	Pearson Correlation	-,625	-,628
	Sig. (2-tailed)	,072	,070
	N	9	9
self-direction	Pearson Correlation	-,653	-,651
	Sig. (2-tailed)	,057	,058
	N	9	9
intimacy	Pearson Correlation	-,514	-409
	Sig. (2-tailed)	,157	,274
	N	9	9
empati	Pearson Correlation	-,663	-,596
	Sig. (2-tailed)	,052	,091
	N	9	9
identity; emotion regulation	Pearson Correlation	-,713*	-,684*
	Sig. (2-tailed)	,031	,042
	N	9	9
Overall LPF	Pearson Correlation	-,620	-,582
	Sig. (2-tailed)	,075	,100
	N	9	9

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 2.

In table 2 the correlations between HF and RMSSD and overall LPFS as well as the sub domains are portrayed. The correlation between the domains and HRV are generally more significant for HF than RMSSD with the exception of the sub domain Identity. Moreover the results are only significant at the 0,05 level for the Emotion Regulation sub facet of Identity, the correlation being 0,031 for HF and 0,042 for RMSSD. HF is also border significantly correlated with the sub domain Empathy at p=0,052. The correlation between overall LPF and HRV is significant neither for HF nor for RMSSD, although the correlation is yet again stronger for HF than RMSSD.

RMSSD	Status	N	Mean	Std. Deviation	t-test	Sig. (2-tailed) 0,028
	Patient	5	30.4000	11,99166		
	Control	4	51.5000	10,47219		

HF	Status	N	Mean	Std. Deviation	t-test	Sig. (2-tailed) 0,025
	Patient	5	473,6000	445,64537		
	Control	4	1305,7500	423,55745		

Table 3.

We also did tests on the correlation between HRV of Patients vs. Controls (table 3). The patients had significantly lower HRV than the controls both using HF (p=0,025) and RMSSD (p=0,028). The HRV was however not significantly lower in the PD group than the control group with p-values of 0,056 for HF and 0,062 for RMSSD.

We will now present the results for the video protocol. The mean score of the amusement inducing clip was 2.75, ranging from 0-5, (3.6 in the patient group and 1,5 in the control group) compared to the neutral clips which were scored 0 on the Likert scale. The mean score of the tenderness inducing clip was 5.375, ranging from 0-10, whereas the neutral clips were scored 0.11 on tenderness. The control group scored higher with a 7 (ranging from 3-10) on tenderness compared to a score of 3.75 (0-8) in the patient group. Not only did the participants rate the clips differently on our Likert scales they also reported varying emotional reactions not related to what we wanted to test, for instance: boredom, “what is happening here”, “Oh that is Johnny Depp as a youngster”, “this is not funny at all!” etc. Because of the large variation in emotional reaction to the clips we consider them unsuitable as an emotional trigger in controlled research. We will however take you through two trajectories (Table 4), one from the patient group and one from the control group, who scored the clips similarly with a four out of ten for the humoristic clip and an eight out of ten for the tenderness clip, without reporting disturbing coreactions.

	RMSSD patient	RMSSD control
Baseline	23	62
Humour	24	75
Neutral	19	73
Vanilla	20	84

Tenderness	24	75
	HF Patient	**HF Control**
Baseline	73	1261
Humour	241	1797
Neutral	276	1544
Vanilla	120	1889
Tenderness	243	2019

Table 4.

The patient in general had a much lower HRV at baseline and the amplitude of the reaction was also a lot smaller for the humoristic clip rising from 73-241 compared to 1261-1797 for the control. While the HF of the patient even rose a bit during the neutral clip it diminished for the control. The vanilla task brought the patient back towards the baseline (276-120), but actually led to an increase in HF (1544-1889) and RMSSD (73-84) for the control. Both had an increase in HF during the watching of the tenderness clip of approximately the same size, but the control had a fall in RMSSD (84-75) while the RMSSD (20-24) of the patient rose.

There is a clear difference in HRV throughout the protocol, HF and RMSSD being a lot larger for the control than the patient. Both participants show reactions to the viewing of the video clips, but the difference between the separate stimuli is a lot larger for the control than the patient RMSSD fluctuating between 62 and 84 and HF between 1261 and 2019 compared to 19-24 and 73-276 respectively.

5. Discussion and conclusion

In this pilot study we aimed to find a correlation or at least a tendency towards a correlation between HRV and LPFS and especially between HRV and Emotion Regulation, a subfacet of the Identity domain of the LPFS. We also aimed to investigate the relationship between positive feelings, namely the PLAY and CARE system (12), the regulation thereof and HRV.

We found significant correlations at the 0,05 level between both HF and RMSSD (our HRV quantifications) and Emotion Regulation, with P-values of 0,031 and 0,042 respectively. Moreover we got border significant results for the sub domain of Empathy and HF (P=0,052) and between Self-Direction and both HF (P=0,057) and RMSSD (P=0,058). The overall LPF score was not significantly correlated with either HF (P=0,075) or RMSSD (P=0,1). We did however get significant results for our patients vs. controls analysis, with P-values of 0,025 (HF) and 0,028 (RMSSD).

The investigation of positive feelings was hampered by the highly variable emotional reactions between patients and controls and between individuals, which was unexpected considering that the video clips were all validated as specific emotion elicitors in a scientific paper (26). By comparing two protocol trajectories, one from a patient and one from a control, we were however able to exemplify the diminished amplitude of HRV regulation (an RMSSD between 19 and 24 and an HF between 73 and 276 for the patient compared to an RMSSD of 62-84 and an HF of 1261-2019 for the control) that can possibly be seen in patients compared to controls in response to stimuli meant to evoke positive feelings.

The significant correlation between HRV and emotional regulation accorded well with our hypothesis, based on Porges' Polyvagal Theory which highlights the tight connection between the ventral vagus complex and other nuclei important to emotional regulation in the medulla, i.e. the facial and trigeminal nuclei controlling vocalization, facial expression and listening. It was thus not surprising that the correlation was strongest between the emotional regulation and HRV, a connection also highlighted by many others (27, 28, 29). We were however not able to find a significant result between HRV and overall LPFS. *Koenig et al.* showed in their meta-analysis that HRV is significantly correlated to bipolar personality disorder (17). Our results indicate a tendency towards that such a correlation is also present between HRV and the severity of PD measured in the LPFS. Our pilot study, however, was all too weak with only 9 participants to expect significant results at this level and even where we found significant results it has to be seen in light of the fact that we had a very helpful control group, with an HRV substantially higher (RMSSD= 51,5 and HF=1305,75) than the means found in *Nunan et al's* systematic review of normal short term HRV values in healthy adults (RMSSD= 42 and HF=657) (30). Another confounding factor is that the control group was examined in calm environments in one of the researcher's home compared to the rather sterile research office in which the patients were examined.

A larger and better controlled study is therefore necessary to confirm the tendencies we found here, in which one should also control for somatic and psychiatric comorbidity, inactivity and medication (especially with anticholinergic effects), shown to be inversely correlated to HRV in a number of studies (31, 32).

6. References

1. Association AP. Diagnostic and statistical manual of mental disorders, 5th edition: DSM-5. Washington, D.C.: American Psychiatric Association; 2013.
2. Lieb K, Zanarini MC, Schmahl C, Linehan MM, Bohus M. Borderline personality disorder. Lancet. 2004;364(9432):453-61.
3. Tyrer P, Reed GM, Crawford MJ. Classification, assessment, prevalence, and effect of personality disorder. Lancet. 2015;385(9969):717-26.
4. Bateman A, Fonagy P. Comorbid antisocial and borderline personality disorders: mentalization-based treatment. JClinPsychol. 2008/2;64(2):181-94.
5. Bales D, van Beek N, Smits M, Willemsen S, Busschbach JJ, Verheul R, et al. Treatment outcome of 18-month, day hospital mentalization-based treatment (MBT) in patients with severe borderline personality disorder in the Netherlands. Journal of Personality Disorders. 2012;26(4):568-82.
6. Karterud S, Pedersen G, Bjordal E, Brabrand J, Friis S, Haaseth O, et al. Day treatment of patients with personality disorders: Experiences from a Norwegian treatment research network. Journal of Personality Disorders. 2003;17(3):243-62.
7. Hopwood CJ, Malone JC, Ansell EB, Sanislow CA, Grilo CM, McGlashan TH, et al. Personality assessment in DSM-5: empirical support for rating severity, style, and traits. Journal of Personality Disorders. 2011;25(3):305-20.
8. Verheul R. Clinical utility of dimensional models for personality pathology. Journal of Personality Disorders. 2005;19(3):283-302.
9. Widiger TA, Simonsen E. Alternative dimensional models of personality disorder: Finding a common ground. Journal of Personality Disorders. 2005;19(2):110-30.
10. Bender DS, Morey LC, Skodol AE. Toward a model for assessing level of personality functioning in DSM-5, part I: a review of theory and methods. Journal of Personality Assessment. 2011;93(4):332-46.
11. Hummelen B, Klungsoyr O, Bøen E, Hornslien AG, Malt UF, Karterud S. Affective instability of borderline personality disorder and bipolar disorder type II measured by ecological momentary assessment. Submitted to Psychological Methods.
12. Panksepp J. Emotional endophenotypes in evolutionary psychiatry. ProgNeuropsychopharmacolBiolPsychiatry. 2006;30(5):774-84.
13. Bateman A, Fonagy P. Mentalization based treatment for borderline personality disorder. World Psychiatry. 2010/2;9(1):11-5.
14. Appelhans, Bradley M., and Linda J. Luecken. "Heart rate variability as an index of regulated emotional responding." *Review of general psychology* 10.3 (2006): 229.
15. Porges, Stephen W. The Polyvagal Theory: Neurophysiological Foundations of Emotions, Attachment, Communication, and Self-regulation (Norton Series on Interpersonal Neurobiology). WW Norton & Company, 2011.
16. Austin, Marilyn A., Todd C. Riniolo, and Stephen W. Porges. "Borderline personality disorder and emotion regulation: Insights from the Polyvagal Theory." *Brain and cognition* 65.1 (2007): 69-76.
17. Koenig, Julian et al. “Resting state vagal tone in borderline personality disorder: A meta-analysis” *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 64 (2016) 18-26
18. Porges, Stephen W. "The polyvagal perspective." *Biological psychology* 74.2 (2007): 116-143.
19. Task force. Heart rate variability: Standards of measurment, physiological interpretation, and clinical use. Task force of the European society of cardiology and the North American Society of Pacing and Electrophysiology. *Circulation*, 1996.

20. Austin, Marilyn A., Todd C. Riniolo, and Stephen W. Porges. "Borderline personality disorder and emotion regulation: Insights from the Polyvagal Theory." *Brain and cognition* 65.1 (2007): 69-76.
21. Bertsch, Katja, et al. "Stability of heart rate variability indices reflecting parasympathetic activity." *Psychophysiology* 49.5 (2012): 672-682.
22. Bender, D., et al., Module I: Structured Clinical Interview for the Level of Personality Functioning Scale, in First MB, Skodol AE, Bender DS, Oldham JM: S). , in Structured Clinical Interview for the DSM-5 Alternative Model for Personality Disorders (SCID-AMPD), M.B. First, et al., Editors. 2014, New York State Psychiatric Institute: New York.
23. Sheehan, D.V., et al., *Mini International Neuropsychiatric Interview (MINI).* Tampa, Florida and Paris, France: University of South Florida Institutt for Research in Psychiatry and INSERM-Hôpital de la Salpétrière., 1994: p.
24. First, M.B., *Structured clinical interview for DSM-IV Axis II personality disorders (SCID II).* 1994, New York: New York State Psychiatric Institute. -.
25. Jennings, J. Richard, et al. "Alternate cardiovascular baseline assessment techniques: Vanilla or resting baseline." *Psychophysiology* 29.6 (1992): 742-750.
26. Schaefer, Alexandre, et al. "Assessing the effectiveness of a large database of emotion-eliciting films: A new tool for emotion researchers." *Cognition and Emotion* 24.7 (2010): 1153-1172.
27. Thayer, Julian F., et al. "A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health." *Neuroscience & Biobehavioral Reviews* 36.2 (2012): 747-756.
28. Berna, Guillaume, Laurent Ott, and Jean-Louis Nandrino. "Effects of emotion regulation difficulties on the tonic and phasic cardiac autonomic response." (2014): e102971.
29. Williams, DeWayne P., et al. "Resting heart rate variability predicts self-reported difficulties in emotion regulation: a focus on different facets of emotion regulation." *Frontiers in psychology* 6 (2015).
30. Nunan, David, Gavin RH Sandercock, and David A. Brodie. "A Quantitative Systematic Review of Normal Values for Short‐Term Heart Rate Variability in Healthy Adults." *Pacing and Clinical Electrophysiology* 33.11 (2010): 1407-1417.
31. Kemp, Andrew H., and Daniel S. Quintana. "The relationship between mental and physical health: insights from the study of heart rate variability."*International Journal of Psychophysiology* 89.3 (2013): 288-296.
32. Berntson, Gary G., and John T. Cacioppo. "Heart rate variability: Stress and psychiatric conditions." *Dynamic electrocardiography* (2004): 57-64.