Journal of Psychopathology and Clinical Psychology / Revista de Psicopatología y Psicología Clínica, 28 **(3), 245-262, 2023**
https://doi.org/10.5944/rppc.37271
https://revistas.uned.es/index.php/rppc
J. Psychopathol. Clin. Psychol. / Rev. Psicopatol. Psicol. Clin.
ISSN 1136-5420

What the heart brings to therapy: A systematic review on heart rate variability contributions to psychotherapy research

Michele Dufey[1], Tamara González[1], Tamara Bravo[1], Ana M. Fernández[2], Paulina Riquelme[1] and Valentina Ramos[1]

[1] *Universidad de Chile, Santiago de Chile, Chile*
[2] *Universidad de Santiago de Chile, Santiago de Chile, Chile*

Abstract: Vagal tone is a psychophysiological construct indexed by heart rate variability (HRV) that is associated with emotion regulation, interpersonal abilities, and mental health in non-clinical and clinical populations. However, the evidence concerning its role in psychotherapy is still limited and no review summarizing the obtained results has been reported to date. The present study aims to fill this gap by presenting a systematic review of psychotherapy studies that evaluate patients' vagal tone regarding process variables and therapy outcomes. The databases SSCI (WoS), EBSCO, and Psychology (ProQuest) database were searched, yielding a total of 23 studies that were qualitatively analyzed. Results showed mixed evidence regarding the predictive value of HRV for clinical outcomes (e.g., symptom level), as well as the effects of psychotherapy on HRV. The association between HRV and working alliance has shown to be consistently positive, although in a smaller number of investigations. Findings are discussed considering HRV assessment conditions and study designs, highlighting the potential value of HRV to inform about the level of psychophysiological resources and autonomic flexibility that individuals bring to therapy.

Keywords: Vagal tone; psychotherapy; heart rate variability; working alliance; psychopathology.

Lo que el corazón trae a la terapia: Una revisión sistemática de las contribuciones de la variabilidad de la frecuencia cardíaca a la investigación en psicoterapia

Resumen: El tono vagal es un constructo psicofisiológico indexado por la variabilidad de la frecuencia cardiaca (VFC) que se asocia con la regulación emocional, las habilidades interpersonales y la salud mental en poblaciones no clínicas y clínicas. Sin embargo, la evidencia acerca de su rol en la psicoterapia sigue siendo limitada y hasta la fecha no se ha presentado ninguna revisión que resuma los resultados obtenidos. El presente estudio pretende llenar este vacío presentando una revisión sistemática de los estudios de psicoterapia que evalúan el tono vagal de los pacientes en relación con las variables del proceso y los resultados de la terapia. Se realizó una búsqueda en las bases de datos SSCI (WoS), EBSCO y Psychology (ProQuest) database, arrojando un total de 23 estudios analizados cualitativamente. Los resultados mostraron evidencia mixta respecto del valor predictivo de la VFC para los resultados clínicos (p. ej., el nivel de síntomas), así como de los efectos de la psicoterapia en la VFC. La asociación entre la VFC y la alianza de trabajo ha mostrado ser consistentemente positiva, aunque en un número menor de investigaciones. Se discuten los hallazgos considerando las condiciones de evaluación de la VFC y el diseño de los estudios, resaltando el potencial valor de la VFC para informar sobre el nivel de recursos psicofisiológicos y la flexibilidad autonómica que los individuos traen a terapia.

Palabras clave: Tono vagal; psicoterapia; variabilidad de la frecuencia cardíaca; alianza de trabajo; psicopatología.

Received: 3 April 2023; accepted: 7 November 2023.
Corresponding author: Michele Dufey, Department of Psychology, Universidad de Chile, Ignacio Carrera Pinto 1045, 7800284 Santiago de Chile, Chile. E-Mail: mdufey@uchile.cl
Acknowledgements: This study was funded by the FONDECYT Initiation grant 11180662 from the Chilean government and sponsored by the Center for Applied Psychology at the Social Sciences Faculty of the University of Chile and the center for psychotherapy and clinical training Centro Arbol SpA.

Introduction

Emotional processes have gained increasing interest in the contemporary study of psychotherapy beyond their historical recognition from different approaches such as humanistic psychology and psychoanalysis (Greenberg et al., 1996; Orange, 1995). In recent decades, the critical

role of emotional processes in the origin and development of psychopathology (Aldao, 2012; Dragan, 2020; Nelson et al., 2020; Sperry et al., 2020), healthy functioning and well-being (Fredrickson & Joiner, 2002; Houben et al., 2015), as well as in psychotherapeutic work (Kramer et al., 2015; Morvaridi et al., 2019; Pascual-Leone et al., 2016) has been evidenced. Likewise, a number of interdisciplinary theories have emerged that show new insights into the complexity of the autonomous nervous system (ANS) concerning emotional life within a neuroanatomical and functional network, highlighting its core role in mediating biobehavioral, emotional, and interpersonal transactions, hence reconceptualizing ANS function. Of particular interest to psychology are the polyvagal theory (Porges, 2009, 2011) and the neurovisceral integration model (Thayer & Lane, 2000, 2009).

The polyvagal theory offers an evolutionary framework to understand the anatomy and function of the ANS by identifying two defense biobehavioral strategies, the mobilization or "fight or flight" and the immobilization or "freezing" strategies, which are dependent on the sympathetic nervous system and the parasympathetic dorsal vagal complex, respectively. When the environment is safe, defensive systems are downregulated by a third biobehavioral strategy named the social engagement system, which relies on a parasympathetic-ventral vagal complex, allowing the emergence of prosocial behaviors (Porges, 2009, 2011). The neurovisceral integration model identifies a central autonomic network that functionally connects the prefrontal cortex with the heart through the vagus nerve, favoring cognitive performance and emotion regulation (Thayer & Lane, 2000, 2009). Although these models have most permeated empirical research, other promising models have also been introduced, such as the resonance frequency breathing model (Lehrer, 2013) that proposes an individualized pattern of paced breathing to increase vagal activity, or the GENIAL model (Kemp, Arias, et al., 2017; Wilkie et al., 2022) which presents an interpretative framework for studying genomic and environmental influences on vagal pathways and, hence, their central role in premature mortality, long-term health and well-being.

A central psychophysiological construct in these theories is the cardiovagal tone (also called vagal tone), which reflects the tonic inhibitory influences of the vagus nerve projecting from the brainstem on the sinoatrial node of the heart and is coupled to the respiratory cycle. Since the vagus nerve is a main branch of the parasympathetic nervous system, it has been considered a valid option to approach parasympathetic function (Brodal, 2010). Operationally, the cardiovagal tone is indexed by the heart rate variability (HRV), representing time differences between adjacent heartbeats (Berntson et al., 1997; Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). There are several methods to assess HRV, the most used being the time-domain and the frequency-domain analyses. Briefly, the time-domain analysis determines the heart rate at any point or the intervals between successive QRS complexes (representing successive ventricle depolarizations) from the continuous electrocardiogram (ECG) recording. Commonly used indexes of time-domain analysis are the root mean square of successive differences between normal heartbeats (RMSSD), which quantifies the amount of variability in time between successive heartbeats, and the respiratory sinus arrhythmia (RSA), reflecting variations in cardiac period coupled to respiratory cycle. The frequency-domain analysis decomposes the signal into different bands, being the high-frequency band (HF), the one that reflects vagal activity (Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996).

A large body of research has shown the relationships between HRV and psychological functioning in non-clinical and clinical populations. On the one hand, a higher HRV has been associated with a more flexible emotion regulation and emotional expression (Balzarotti et al., 2017; Bulut et al., 2018; Demaree et al., 2004; Fabes & Eisenberg, 1997; Nasso et al., 2019; Pu et al., 2010), a greater expression of positive (Oveis et al., 2009) and prosocial emotions (Kok & Fredrickson, 2010; Stellar et al., 2015), as well as less avoidance of social interactions (Geisler et al., 2013). On the other hand, an atypical cardiovagal control pattern (e.g., decreased HRV reactivity; Austin et al., 2007) and a decreased HRV (Koenig et al., 2016) have been observed in borderline personality disorder and a decreased HRV in anxiety disorders (Campbell et al., 2019; Chalmers et al., 2014), depression (Dubey & Sawane, 2017; Hartmann et al., 2019; Kemp et al., 2010; Licht et al., 2008; Yeh et al., 2016), bipolar disorder (Hage et al., 2019), psychological distress and aggressive behavior (Liddell et al., 2016), burnout (Lennartson et al., 2016; Wekenborg et al., 2019) and internalizing psychopathology (McLaughlin et al., 2015). Most of the research in the field has been conducted in experimental settings and, to a lesser extent, concerning emotions in daily life. However, there is an increasing interest in studying individuals' HRV regarding psychotherapy due to its potential value to inform about symptom onset (i.e., depressive symptoms; Jandackova et al., 2016) and its diagnostic

value concerning individuals' health status (Beauchaine, 2015; Heiss et al., 2021). In this context, the main aim of the present study was to conduct a systematic review of empirical research that included HRV in the investigation of psychotherapeutic interventions, summarizing the main findings and obtaining relevant conclusions that could be useful for planning future research, filling a gap in current literature.

Method

The databases SSCI (WoS), EBSCO, and Psychology (ProQuest) were searched through the program Mendeley, entering the following search equation: ab(psychotherapy OR therapy OR counseling OR working alliance OR therapeutic relationship OR clinical practice OR clinical interventions) AND ab(HRV OR RSA OR vagal tone OR parasympathetic OR cardiovagal control). According to the inclusion criteria, the studies needed to be empirical, in English, published since 2000, conducted with an adult population, assess HRV in relation to psychotherapeutic interventions, and include the results of the therapy and/or therapeutic process measures.

For a flow diagram of the study selection process see Figure 1. The initial search was carried out in January 2020. After eliminating finding duplicates, remaining texts were divided into three groups and reviewed independently (title and abstract) by the second, third, and fifth author to determine compliance with the inclusion criteria. Once reviewed, the eligibility of the studies was discussed with the first author and the remaining texts were fully read by the second, third, and fifth author. After eliminating texts that did not meet the inclusion criteria and adding seven texts from reference lists of other studies, 23 studies entered the qualitative analysis. A content analysis was conducted that considered the following stages: a) initial reading and familiarization with the data, b) coding and definition of categories and subcategories, and c) description and systematization of the findings (Elo & Kyngäs, 2008).

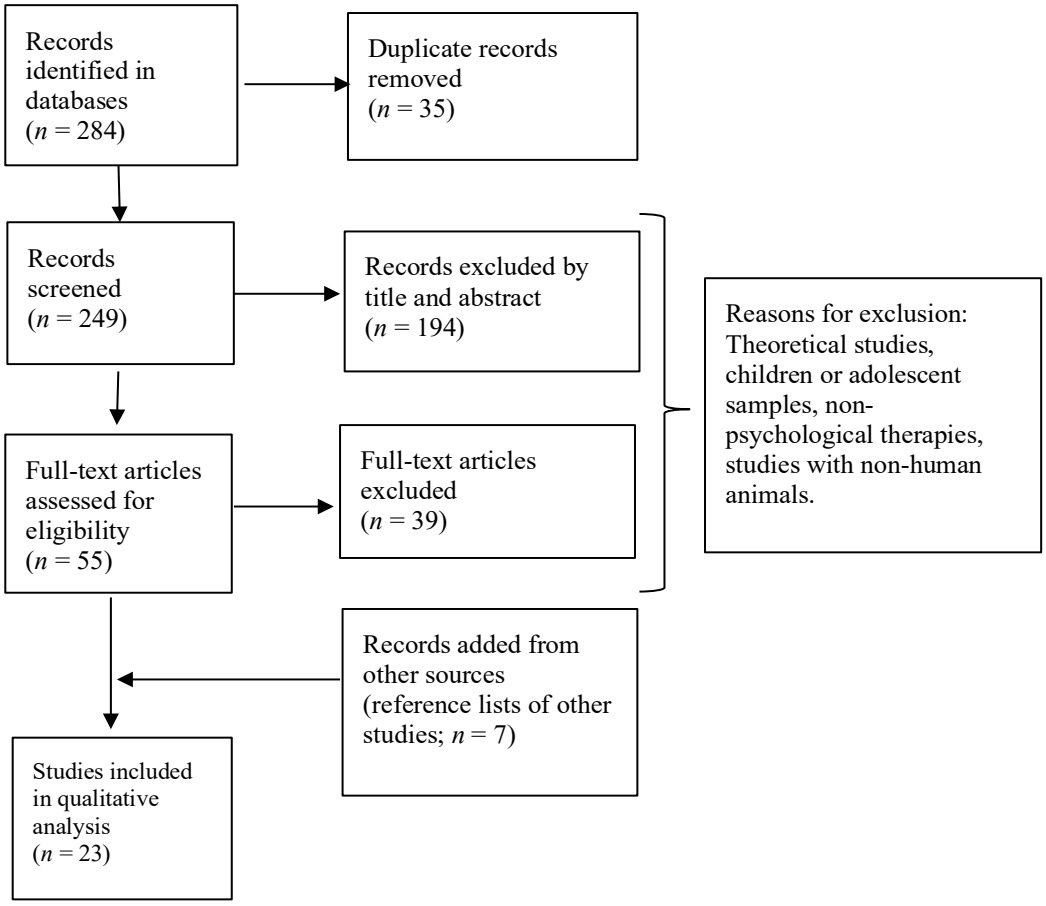

Figure 1. Flow diagram of the study selection process.

Results

A total of three main themes and four subthemes emerged from the qualitative analysis, i.e., 1. treatment and sample characteristics, 2. conditions of HRV assessment, 3. HRV and therapy outcomes, 3.1 HRV predicting clinical outcomes, 3.2 HRV as a treatment target, 3.3 HRV and the therapy process, and 3.4 case studies. Studies that used HRV in multiple analyses (i.e., HRV as an independent and dependent variable) were reported in more than one thematic category. Since the primary goal of this study was to summarize contributions of HRV variables related to parasympathetic activity in psychotherapy, other cardiac (e.g., heart rate or low-frequency HRV) or psychophysiological parameters (e.g., skin conductance) were not included in the analyses. Table 1 summarizes the studies and shows specific HRV parameters considered across research.

Overview of treatments and sample characteristics

HRV has been investigated through diverse psychotherapeutic orientations and individual or group treatment modalities. Most corresponded to brief therapy modalities and several studies contrasted one therapeutic intervention with a control condition or two different therapeutic interventions with or without a control condition. The most prevalent clinical orientation was cognitive behavioral therapy (CBT) and CBT variants, e.g., for substance abuse disorder (Blanck et al., 2019; Caldwell & Steffen, 2018; Soder et al., 2019), in forest environments (Kim et al., 2009), combined with biofeedback (Angelovski et al., 2016), and mindfulness-based (Howells et al., 2013). Other orientations were a diversity of psychodynamic therapies (Angelovski et al., 2016; Milrod et al., 2016; Stratford et al., 2014; Zimmermann-Viehoff et al., 2016), group positive psychotherapy (Lü et al., 2013), and eclectic or miscellaneous approaches (Balint et al., 2022; Doukas et al., 2014). A total of 960 participants (excluding psychotherapists) of which 743 received psychotherapy were included in the review. Regarding the clinical characteristics of the samples, anxiety conditions with anxiety disorder as the primary condition were most prevalent (Blanck et al., 2019; Garakani et al., 2009; Stratford et al., 2014; Sullivan et al., 2004). Other disorders of lower prevalence in the literature were anxiety or other mood disorders (Wheeler et al., 2014), posttraumatic stress disorder (PTSD; Doukas et al., 2014) and PTSD comorbid with substance abuse disorder (Soder et al., 2019), separation anxiety disorder (Milrod et al., 2016), depressive disorder (Blanck et al., 2019; Caldwell & Steffen, 2018; Carney et al., 2000; Kim et al., 2009; Neyer et al., 2021; Zimmermann-Viehoff et al., 2016), bipolar disorder (Howells et al., 2014), somatoform disorders (Angelovski et al., 2016; Zimmermann-Viehoff et al., 2016), adjustment disorder (Zimmermann-Viehoff et al., 2016), low trait positive affect (Lü et al., 2013), and mental or psychosomatic symptoms in general (Balint et al., 2022).

Two studies incorporated therapists' assessment to determine interactions between patients' and therapists' psychophysiological parameters and measures of the therapeutic process (Blanck et al., 2019; Stratford et al., 2014).

Conditions of HRV assessment

Several studies assessed baseline HRV through different protocols. Some studies measured it in a free task condition of five minutes, in a sitting position (Blanck et al., 2019; Kim et al., 2009; Soder et al., 2019), or applying other evaluation times such as two (Doukas et al., 2014), three (Angelovski et al., 2016) or 10 minutes (Cadwell & Steffen, 2018). These designs align with established recommendations for obtaining a short baseline vagal tone (Laborde et al., 2017; Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). Other studies assessed baseline HRV through a task, such as observing a neutral image (a cup [Lü et al., 2013] or a color detection task [vanilla task; Feldman et al., 2016]) or reacting to a trauma or substance-related script (scripted cue-reactivity task; Soder et al., 2019; however, in their analyses, the authors only considered the free-task period).

HRV reactivity has been considered to a lesser extent through heterogeneous procedures. Angelovski et al. (2016) measured HRV reactivity when the participant responded to a mental stress task (the Stroop Test). In this case, HRV reactivity refers to a single condition. Other studies assessed HRV reactivity considering two or three different moments in time, either during a resting condition followed by an affective visual task and a recovery period (Doukas et al., 2014) or through three different experimental conditions that were repeated before and after completing the treatment (Howells et al., 2014). Doukas et al. (2014) adopted a recommended design for HRV reactivity assessment, including a free-task recovery period, allowing a conventional interpretation of their findings. Howells et al. (2014) evaluated HRV reactivity through a one-hour visual matching task that included three experimental conditions to assess emotional processing: object matching, affect

Table 1. Summary of studies

Study	Participants	Psychotherapy	Measures		Results	
			Clinical	HRV	Clinical outcomes	HRV
Angelovski et al. (2016)	*n* = 106 with MSD randomized to psychotherapy or EMC	PIT, 12 sessions once per week	PCS, PHQ-15, PHQ-9	Pre-treatment RMSSD and HF-HRV in four steps: 1) 3-min resting state, 2) Stroop Color and Word Test, 3) guided paused respiration, 4) 3-min resting state	Psychotherapy group improved in physical quality of life and pain symptoms (PCS) when compared to EMC group in the 9-month follow-up	Only for the psychotherapy group: baseline RMSSD and HF-HRV were directly correlated with improvements in pain symptoms; baseline HF-HRV was directly correlated with improvements in quality of life; higher resting RMSSD had an increased proportion of therapy responders
Balint et al. (2022)	*n* = 23 outpatients receiving therapy at the workplace with mental health or psychosomatic complains	Up to 12 sessions of CBT combined with psychodynamic principals, weekly or every two weeks	SF-12; PHQ-9, irritation scale	24-hour HRV-HF and RMSSD assessed at the beginning and end of therapy	Presented with HRV results in the next column	Higher early RMSSD and HRV-HF predicted lower overall symptom levels (SF-12 and PHQ-9) at the end of therapy
Blanck et al. (2019)	*n* = 53 patients with anxiety disorder and MDD, *n* = 24 therapists	CBT, 25-week individual sessions	SCID (DSM-V), WAI-BDI-II	HF-HRV in a 5-min resting condition before and in the middle of session 2, 5, 15 and 24	Depressive symptoms (BDI-II) improved from pre- to post-treatment	Early baseline HF-HRV predicted pre- to post-therapy decreases in depressive symptoms; early baseline HRV improved from pre- to post-therapy but was not related to symptom change; patients' in-session HRV positively predicted patients' ratings of working alliance
Butner et al. (2017)	*n* = 3, one heterosexual married couple and a therapist	IBCT, 26 sessions, only the first session is analyzed	WAI-S, TPI	In-session HRV (RSA)	Authors only report descriptives of WAI-S and TPI	Therapist's fundamental frequency (f0) was moderated by husband's HRV
Caldwell & Steffen (2018)	*n* = 30, with MDD and healthy controls	HRV-B + CBT, just CBT, and control group without intervention, six weeks	MINI, BDI-II	10-min resting HRV (SDNN and HF-HRV) at pre-treatment and 6-week follow-up	HRV-B group showed the largest decrease in depressive symptoms (BDI-II)	Baseline HRV increased from pre- to post-therapy in HRV-B + CBT; decrease in depressive symptoms was mediated by HRV gains
Carney et al. (2000)	*n* = 30 depressed patients with stable coronary heart disease and a non-depressed control group	Individual outpatient CBT for 16 weeks	DIS, BDI	RMSSD obtained from a 24-hour ECG at the beginning of treatment and in a 4-month follow-up	Decrease in depressive symptoms (BDI) in depressed group	Day-time HRV (RMSSD) increased from pre- to post-therapy in more impaired depressive patients

Table 1. Summary of studies *(cont.)*

Study	Participants	Psychotherapy	Measures		Results	
			Clinical	HRV	Clinical outcomes	HRV
Doukas et al. (2014)	*n* = 27 women with PTSD symptoms	Several treatment orientations: Psychodynamic, CBT, and dialectic-behavioral; 12 sessions once a week	BSI, PCL, DES, WAI-S, THQ	RSA obtained in four epochs (2-min baseline followed by a slide task – 2 blocks of 10 positive and 10 trauma-related slides – and a 2-min recovery period), before and after therapy	No statistically significant relationship between symptom change (BSI, PCL, and DES) and working alliance scores	Baseline RSA and RSA during positive slides before therapy predicted greater global working alliance (WAI-S) after therapy
Feldman et al. (2016)	*n* = 53 Latinos with asthma and panic disorder	CBPT or MRT weekly for eight weeks	PDSS, CGI, ASI-3	Resting HF-HRV during a 5-min plain vanilla baseline task followed by 5-min breathing at resonance before, during and after treatment, and at 3-month follow-up	Both groups showed improvements in panic disorder severity (PDSS) from baseline to post-treatment and 3-month follow-up	No changes in HF-HRV
Fleury et al. (2016)	*n* = 1, woman with panic disorder	Psychodynamic therapy, 23 sessions once a week, only session 1 and 5 were analyzed	MINI, OQ-45	In-session RSA and CVI	Decrease in symptom severity (OQ-45) across sessions	Specific emotions (anxiety, rage, and guilt) were associated with different patterns of HRV activity
Garakani et al. (2009)	*n* = 43 patients with panic disorder, 11 healthy controls	CBT for panic control, weekly sessions for 12 weeks + sertraline if requested	CGI, HAM-A, HAM-D, API, PDSS, BORG, MI, SRLE, and an anxiety scale	15-min resting HRV (PNN50 and HF-HRV) in supine position followed by a 10-min hyperventilation period before and after therapy	Treatment improved all clinical measures (HAM-A, HAM-D, PDSS, CGI, MI, and SRLE)	Patients had lower resting and hyperventilation HRV(PNN50) than controls at pre-treatment; treatment reduced all behavioral measures (API, BORG and anxiety scale) during resting and hyperventilation periods and increased HRV (PNN50) in treatment responders
Howells et al. (2013)	*n* = 21, with euthymic bipolar I disorder and healthy controls	MBCT, 8 sessions once a week	YMRS, HADS, SCID	HF-HRV reactivity across three experimental conditions (object matching, affect matching, and affect labeling)	No changes in clinical symptoms (YMRS and HADS) for any group	HF-HRV decrease from pre- to post-treatment in bipolar group
Kim et al. (2009)	*n* = 63 patients with MDD assigned to a forest psychotherapy group, a hospital psychotherapy group or a control group	Group CBT in a forest environment or in a hospital, or usual outpatient management, four weeks	SCID (DSM-IV-TR), SF-36, HRSD, MADRS, BDI	5-min resting HRV (RMSSD and HF-HRV)	Higher remission of depressive symptoms in the forest group (HRSD and MADRS)	HF-HRV and RMSSD increased significantly from pre- to post-treatment in the forest group

Table 1. Summary of studies *(cont.)*

Study	Participants	Psychotherapy	Measures		Results	
			Clinical	HRV	Clinical outcomes	HRV
Lü et al. (2013)	*n* = 70, HPA and LPA, LPA assigned to a positive psychotherapy or a control group	Group positive therapy, 16 weekly sessions	PANAS	5-min resting HRV (RSA and HF-HRV) before and after therapy	Trait positive affect (PANAS) increased after therapy	Baseline HRV (RSA and HF-HRV) increases from pre- to post-therapy in the therapy group; pre- to post-changes in trait positive affect (PANAS) were predicted by pre- to post-changes in baseline HRV
Mathewson et al. (2013)	*n* = 23 patients with social anxiety disorder	Group CBT for social anxiety, 12 weeks	SCID (DSM-IV), SPIN, ERQ	Resting 6-min ECG at four time points (two and one week before, in the middle and at the end of treatment), RSA derived from HF-HRV	Therapy responders showed higher levels of reappraisal and lower levels of suppression use (ERQ) than therapy non-responders	Resting RSA decreased similarly from pre- to post-therapy in therapy responders and non-responders; change in resting RSA was a better predictor of anxiety reduction than baseline RSA before therapy; RSA and reappraisal (ERQ) together were the best predictors of anxiety reduction (SPIN)
Milrod et al. (2016)	*n* = 46, with clinically significant anxiety symptoms, 80% had clinically significant separation anxiety symptoms	PFPP-XR, 21-24 sessions, 12 weeks	SCI-SAS, ADIS-IV, CGI-S, HAM-A, HRSD	20-min resting HRV(HF-HRV) before and after treatment	Significant improvement in anxiety symptoms from pre- to post-therapy (SCI-SAS, HRSD, CGI-S, HAM-A)	No changes in HRV
Neyer et al. (2021)	*n* = 50 inpatients with MDD	Individual and group therapy (i.e., MBT, MeBT, social skills training and psychoeducation for depressive disorders)	HRSD, BDI-II	5-min resting RMSSD and HF-HRV obtained three times during the first and the last week of therapy	Significant decrease in depressive symptoms (HRSD, BDI-II) from pre- to post-intervention	RMSSD was negatively correlated with depressive symptoms (HRSD, BDI-II) before therapy; HRV parameters remained unchanged from pre- to post-intervention and were no longer correlated with the decreased depressive symptoms after therapy
Norte et al. (2011)	*n* = 1, man with PTSD	16 CBT sessions, 48 additional coaching sessions 3 times per week	PCL-C, BDI, BAI, PANAS-T, ER89, MOSS-SS	5-min resting HF-HRV before and after treatment	Improvement in PTSD (PCL-C) symptoms from pre- to post-intervention	HF-HRV enhancement of 40.6% from pre- to post- treatment

Table 1. Summary of studies *(cont.)*

Study	Participants	Psychotherapy	Measures		Results	
			Clinical	HRV	Clinical outcomes	HRV
Soder et al. (2019)	*n* = 37 patients with SUD and at least four PTSD symptoms	CBT for SUD or TIPSS, 12 sessions for 6 weeks	CAPS-5, TLFB	5-min resting HF-HRV and in response to a scripted cue-reactivity paradigm prior to treatment, only the 5-min resting period was included in the analyses	Presented with HRV results in the next column	Higher baseline HF-HRV predicted greater reduction in PTSD symptoms (CAPS-5) from pre- to post-therapy in both conditions
Steffen et al. (2020)	*n* = 31 college students	GCFT, 12 sessions	OQ-45, CEAS, FSCRS, AAQ	10-min resting SDNN and HF-HRV followed by 5-min self-critical writing, 5-min self-compassionate writing, and a 10-min recovery period, before and after therapy	Presented with HRV results in the next column	Increased HRV reactivity (SDNN and HF-HRV) at pre-intervention predicted decreased distress (OQ-45) at post-intervention; SDNN reactivity increased from pre- to post- intervention in participants with improvements in self-compassion (CEAS); security attachment (AAQ) positively predicted SDNN reactivity at post-intervention
Stratford et al. (2014)	*n* = 30, with anxiety symptoms	Psychodynamic therapy, 6 sessions once a week	STAI, POMS, WAI-P, WAI-T	In-session HF-HRV	Working alliance (WAI-P) progressively increased from session 1 to 6	HF-HRV showed an increasing trend after session 1 peaking in session 4, then decreased from session 4 to 6, being higher in session 6 than in session 1
Sullivan et al. (2004)	*n* = 16, with panic disorder	Individual CBT for panic disorder, 12 weekly sessions	PDSS, HAM-A, CGI-S, CGI-I, API, anxiety scale, RPE	10-min resting SDNN and HF-HRV followed by a 15-min hyperventilation period in supine position	Improvements in clinical and medical symptoms (CGI-S and PDSS) from pre- to post-intervention	No variations in HRV from pre- to post-therapy
Wheeler et al. (2014)	*n* = 27 outpatients with mood or anxiety disorder	GMBCT, eight weeks	SF-36, CES-D	20-min SDNN, RMSSD, HF-HRV and HRV triangular index, obtained in a supine position before and after a Stroop test at three different time points (twice before and once after therapy)	Significant improvement in the SF-36 physical summary score and a decrease in self-reported depressive symptoms (CES-D)	No changes in any HRV parameter

Table 1. Summary of studies *(cont.)*

Study	Participants	Psychotherapy	Measures		Results	
			Clinical	HRV	Clinical outcomes	HRV
Zimmermann -Viehoff et al. (2016)	*n* = 135 inpatients with different diagnoses	Multimodal psychodynamic treatment for 15 to 29 days	GSI, HADS	5-min resting RMSSD and HF-HRV in a paced breathing condition assessed at the beginning and end of treatment	Significant improvements in all clinical outcomes (GSI and HADS)	RMSSD decreases from pre- to post-intervention

Note. AAQ = Adult Attachment Questionnaire; ADIS-IV = Anxiety Disorders Interview Schedule for DSM-IV; API = Acute Panic Inventory; ASI-3 = Anxiety Sensitivity Index-3; BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; BDI-II = Beck Depression Inventory-II; BORG = Borg Breathlessness Scale; BSI = Brief Symptom Inventory; CAPS-5 = Clinician-Administered PTSD Scale for DSM-5; CBPT = cognitive behavior psychophysiological therapy; CBT = cognitive behavioral therapy; CEAS = Compassionate Engagement and Action Scales; CES-D = Center for Epidemiologic Studies Depression Scale; CGI = Clinical Global Impressions Scale of the SCL-90; CGI-I = Clinical Global Impressions – Improvement Scale; CGI-S = Clinical Global Impressions – Severity Scale; CVI = cardiac vagal index; DES = Dissociative Experiences Scale; DIS = Diagnostic Interview Schedule from the National Institute of Mental Health; EMC = enhanced medical care; ER89 = Ego-Resiliency Scale; ERQ = Emotion Regulation Questionnaire; FSCRS = The Forms of Self Criticism and Self Reassuring Scale; GCFT = group compassion focused therapy; GMBCT = group mindfulness based cognitive therapy; HADS = Hospital Anxiety and Depression Scale; HAM-A = Hamilton Rating Scale for Anxiety; HAM-D = Hamilton Rating Scale for Depression; HF-HRV = high-frequency heart rate variability; HPA = high positive affect group); HRSD = Hamilton Rating Scales for Depression; HRV = heart rate variability; HRV-B = heart rate variability biofeedback; IBCT = integrative behavioral-cognitive therapy for couples; LPA = low positive affect group; MADRS = Montgomery-Asberg Depression Rating Scale; MBCT = mindfulness-based cognitive therapy; MBT = mindfulness-based therapy; MeBT = mentalization based therapy; MDD = major depressive disorder; MI = Mobility Inventory for Agoraphobia; MINI = The MINI International Neuropsychiatric Interview; MOSS-SS = Medical Outcomes Study's Social Support Scale; MRT = music relaxation therapy; MSD = multisomatoform disorder; OQ-45 = Outcome Questionnaire-45; PANAS = Positive and Negative Affect Schedule; PANAS-T = Positive and Negative Affect Schedule − Trait Version; PCL = PTSD Checklist; PCL-C = PTSD Checklist-Civilia; PCS = The Physical Component Summary of the SF-36 Short Form Health Survey; PDSS = Panic Disorder Severity Scale; PFPP-XR = Panic-Focused Psychodynamic Psychotherapy – eXtended Range; PHQ-15 = Patient Health Questionnaire somatic symptom severity scale; PHQ-9 = Patient Health Questionnaire-9; PHQ-15 = Patient Health Questionnaire-15; PIT = psychodynamic interpersonal therapy; POMS = The Profile of Mood States; PTSD = post-traumatic stress disorder; RMSSD = root mean square of successive differences between normal heartbeats; RPE = Borg Scale of Exertion; RSA = respiratory sinus arrhythmia; SCID = Structured Clinical Interview; SCI-SAS = Structured Clinical Interview for Separation Anxiety Symptoms; SCL-90-R GSI = Global Severity Index of the Symptom Checklist 90-R; SD = somatoform disorder; SDNN = standard deviation of normal intervals; SF-12 = Short Form Health Survey Questionnaire-12; SF-36 = Short Form Health Survey Questionnaire-36; SPIN = Social Phobia Inventory; SRLE = Survey of Recent Life Experiences Scale; STAI = Spielberger State-Trait Anxiety Inventory; SUD = substance use disorder; THQ = Trauma History Questionnaire; TIPPS = treatment of integrated post-traumatic stress and substance use; TLFB = Timeline Followback; TPI = Therapeutic Presence Inventory; WAI-P = Working Alliance Inventory for patients; WAI-S = Working Alliance Inventory – Short for therapist and patients; WAI-SR = Working Alliance Inventory – Short Revised for therapist and patients; WAI-T = Working Alliance Inventory for therapists; YMRS = Young Mania Rating Scale.

matching, and affect labeling. In both cases, a design was used that allows inferring the response of vagal activity related to a standard event (i.e., an emotional picture) from pre- to post-intervention.

HRV and therapy outcomes

HRV predicting clinical outcomes. There were six studies on this topic. Three used baseline HRV obtained before or at the beginning of therapy (i.e., after the second session) to determine its predictive value for symptom change at therapy completion or follow-up. Another two studies added HRV reactivity to their analyses and one study used a 24-hour assessment of HRV.

One line of evidence has shown that baseline HRV obtained before or early in treatment predicts symptom change. Specifically, in a mixed sample of depressed and anxious patients, the baseline HRV obtained after the second session was an inverse predictor of depressive symptoms at the end of therapy (Blanck et al., 2019). Similarly, in a sample of patients diagnosed with PTSD who received one of two treatment modalities (CBT or treatment of integrated post-traumatic stress and substance use), a higher pre-treatment baseline HRV predicted greater reduction in PTSD symptoms in both therapy modalities (Soder et al., 2019). Another study also assessed baseline HRV and HRV reactivity in two treatment modalities (psychodynamic interpersonal psychotherapy vs. medical enhanced care) in patients with somatoform disorder, along with clinical measures for specific body symptoms and depression (Angelovski et al., 2016). No associations were found between psychophysiological and clinical measures at the beginning of treatment in neither group; however, a higher baseline HRV and greater HRV reactivity predicted a positive change in physical quality of life

(pain and somatization) in a nine-month follow-up in the psychotherapy group. When the psychotherapy group was median-splitted based on baseline HRV, the high HRV group included a greater proportion of psychotherapy responders than the low HRV group. Finally, in a study of therapy implemented at the workplace with employees experiencing mental or psychosomatic health complaints, a higher HRV early in therapy was predictive of lower symptom burden at the end of treatment (Balint et al., 2022).

Two studies found no associations between early therapy HRV measures and clinical outcomes. Specifically, in women diagnosed with interpersonal trauma, no associations were observed between pre-therapy HRV (baseline HRV, HRV reactivity, and HRV recovery) and pre- to post-clinical outcomes (general psychiatric distress and PTSD symptoms; Doukas et al., 2014). Even though the authors emphasized other aspects of therapy in their analyses (i.e., psychophysiological outcomes related to working alliance, as will be presented below), they refer that actual symptom change may have been underrepresented due to the use of self-report measures in a sample that may present affective recognition deficits or alexithymia. In another study, early baseline HRV along with clinical status (global severity, depression, and anxiety) were obtained in a sample of inpatients diagnosed with a variety of psychiatric disorders (i.e., somatoform disorders, adjustment disorder, major depression, eating disorders, anxiety disorders, and other diseases; Zimmerman-Viehoff et al., 2016). Although all clinical measures had decreased significantly after treatment, no significant associations were found between initial HRV parameters and clinical status from pre- to post-therapy.

The lack of an association between pre-treatment or early HRV and therapy outcomes could indicate the importance of considering specific treatments and outcome measures according to the characteristics of different clinical populations when assessing HRV. For example, Angelovski et al. (2016) and Soder et al. (2019) implemented therapies designed to address the specific requirements of clinical samples with PTSD and somatoform disorder, respectively, and used specific measures to assess core symptoms in each diagnostic category. On the other hand, treatments may not have been entirely adequate for the clinical requirements of the patients. For instance, in Zimmerman-Viehoff et al. (2016), patients showed a broad range of clinical disorders, were treated with a general multimodal treatment, and clinical outcomes were assessed through a general symptom index, along with depression and anxiety scales. Similarly, in Doukas et al. (2014), therapy was delivered using various clinical orientations.

HRV as a treatment target (dependent variable). Sixteen studies were grouped under this theme. HRV parameters and clinical status were assessed at different time points regarding treatment to determine its impact on clinical outcomes and psychophysiological activity.

Several studies found a positive effect of psychotherapy on HRV parameters, and most of these gains were associated with positive clinical outcomes. In all these studies, one or more comparison groups were included in their designs. A first psychotherapy study introducing patients' HRV assessment was carried out under the hypothesis that patterns of HRV in depressed patients might have prognostic relevance, particularly in moderate and severe forms of depression, and that psychotherapy would improve their prognosis (Carney et al., 2000). Specifically, the twenty-four-hour HRV was assessed before and after therapy along with depressive symptomatology in a group of depressed patients with coronary heart disease and a healthy control group to determine whether HRV parameters were increased after therapy. As hypothesized, after therapy, depressive symptoms were significantly decreased in the group of patients and the daytime HRV was significantly increased in those patients who presented more severe symptoms of depression.

Other studies have added evidence in favor of the rationale that HRV can be a valid target of psychotherapy and most of them were also conducted with depressed individuals. For instance, Kim et al. (2009) included three comparison groups: psychotherapy administered in a forest environment, hospital outpatient treatment, and a control group without treatment, evidencing an increase in baseline HRV from pre- to post-treatment only in the forest group (which also showed a greater reduction in depressive symptoms). A similar pattern of baseline HRV increments from pre- to post-treatment was only observed in a group diagnosed with major depressive disorder receiving HRV biofeedback and psychotherapy when compared with two other groups, one receiving therapy as usual and the other being a healthy control group that did not receive psychotherapy (Caldwell & Steffen, 2018). Additionally, in Blanck et al. (2019), both baseline HRV and depressive symptoms improved throughout psychotherapy, although baseline HRV increments were unrelated to symptom change. The authors discuss different possibilities for this outcome: patients may experience fewer depressive symptoms at the end of therapy without a correlate in vagal tone; high vagal tone may not be adaptive in all circumstances; and other outcomes might be observed

with longer recording periods of HRV (e.g., 24 hours). Beyond the authors' considerations, another possibility is that there was a selection effect because the sample had mixed characteristics (56.7% and 43.4% diagnosed with depression and anxiety, respectively). Accordingly, the fact that clinical outcomes were only determined by depressive symptoms may not have been suitable to detect changes in the subgroup of patients with anxiety as the primary diagnosis. Similar results regarding pre- to post-therapy HRV improvements coupled with positive clinical outcomes were observed in patients diagnosed with panic disorder classified as treatment responders (Garkani et al., 2009) and in low-trait positive affect individuals (Lü et al., 2013). This evidence indicates that psychotherapy may have a beneficial impact on patients' autonomic activity allowing a strengthening of their psychophysiological resilience. The inclusion of comparison groups or a control condition suggests that the effects on HRV may be attributable to the specificity of psychotherapy or treatment modality rather than to spontaneous change in autonomic functioning.

Other studies found evidence of no changes or even a decrease in baseline HRV from pre- to post- treatment. On the one hand, some studies observed improvements in clinical outcomes with no variations in HRV in a diversity of clinical samples, such as non-responders to previous treatments who received a specific intervention for separation anxiety (Milrod et al., 2016), inpatients diagnosed with major depressive disorder (Neyer et al., 2021), patients diagnosed with panic disorder (Feldman et al., 2016; Sullivan et al., 2004), outpatients with a primary diagnosis of either a mood or anxiety disorder (Wheeler et al., 2014), and outpatients with mental or psychosomatic complaints (Balint et al., 2022). Additionally, the same pattern of a positive psychological impact of therapy without HRV variations was observed in a non-clinical sample of healthy college students who received compassion-focused therapy (Steffen et al., 2020).

On the other hand, improvements in clinical outcomes with HRV decreases have also been reported, which has been considered as an unexpected situational effect of the testing conditions. For instance, Zimmerman-Viehoff et al. (2016) pointed out a possible distressing effect of having carried out psychophysiological assessments at medical discharge and a possible adverse effect of having applied high-dose psychotherapy, while Matthewson et al. (2013) suggested that having performed psychophysiological assessments just before a challenging task (preparing an oral presentation) might have affected resting HRV by the anticipation of the task leading to a parasympathetic withdrawal during the assessments.

Two studies focused on task-related HRV changes from pre- to post-intervention as a proxy of emotional engagement. In Steffen et al. (2020), HRV reactivity was derived from an emotionally engaging task (self-critical and self-compassionate writing) performed before and after treatment. It was observed that higher pre-therapy HRV reactivity to self-critical tasks negatively predicted post-intervention distress levels. In patients diagnosed with bipolar disorder (BD), a task-related HRV was measured across three experimental conditions (visual object match, affect match, and affect labeling) before and after therapy (Howells et al., 2014). Compared to controls, the BD group showed increased HRV peaks before therapy and decreased HRV peaks after therapy, with no variations in clinical outcomes. The authors interpreted these findings as evidence of a stable euthymia expression with an impaired, exaggerated physiological response to emotional processing in BD that can be modulated by therapy.

HRV and the therapy process. Three studies were grouped under this theme. HRV was assessed before therapy or in-session, and all studies found a positive association with working alliance (WA). Specifically, in anxious patients, in-session HRV and WA showed different patterns across six therapy sessions (Stratford et al., 2014). While WA progressively increased from session 1 to 6, HRV showed an increasing trend after session 1 peaking in session 4 and then decreased from session 4 to 6, although still being higher in session 6 than in 1. According to the authors, HRV reflects the patient's potential for relaxed involvement in therapy, which is critical for WA formation and the patient's engagement in psychotherapy-related tasks. Similarly, when assessing in-session HRV and WA across four different therapy sessions (1, 5, 15, and 24), the patient's in-session HRV positively predicted the patient's WA ratings (Blanck et al., 2019). The authors speculate about possible reciprocal influences between vagally-mediated HRV, the social behavior patients displayed in sessions, and the perception of a safe therapeutic environment that favors a good therapeutic alliance, which, in turn, might stimulate vagally-mediated HRV. They point to the relevance of including the observation of in-session behavior in the future (e.g., through video recordings) to explore the relationship between psychophysiological and subjective assessments and the contingent behavior of patients and therapists.

HRV has also been considered a pre-therapy patient factor that may be relevant to understanding the difficulties for engaging in the therapeutic relationship when trauma-related symptoms exist. Pre-therapy baseline HRV and HRV related to an experimental

emotional task (observing positive slides) were direct predictors of overall WA at the end of therapy (Doukas et al., 2014). The authors point to the relevance of considering the patients' ability to mobilize their parasympathetic resources during periods of relatively low-stress and positive discussion in therapy to favor their engagement in the therapeutic relationship, particularly when there is a history of interpersonal violence. Likewise, the authors discuss the therapeutic potential of introducing techniques or interventions that positively mobilize the parasympathetic nervous system early in therapy (e.g., yoga exercises).

Case studies. Three case studies used a descriptive approach to a single-case analysis of one or two sessions or explored more complex methods for assessing in-session psychophysiological interactional synchrony. Such descriptive studies offer the opportunity for an enriched characterization of cases, deeper symptom-related information, information about life backgrounds and the therapy process. Specifically, in one study with a PTSD case, improvements in cognitions and behaviors related to symptoms were observed from pre- to post-therapy, along with a 40.6% increase of baseline HRV activity (Norte et al., 2011). Another study adopted the psychophysiological approach to describe how emotions are embodied in therapy as an expression of underlying unconscious regulation defensive strategies (Fleury et al., 2016). Here, the pattern of psychophysiological activity related to therapy content (e.g., patient expresses unconscious guilt or anxiety) was explored across two therapy sessions, observing an overall increase in HRV activity within each session and a progressive symptom decrease across sessions. In another study conducted during couple therapy, the first session was analyzed to determine exchange patterns between dyadic subsets of the therapeutic system (e.g., therapist-wife, wife-husband) and the whole group as a unit (i.e., therapist-wife-husband). Using dyadic cross-lagged panel analyses, it was observed that the psychophysiological activity of the husband moderated the therapist's prosody, having a stabilizing effect on the therapist's prosody when the husband's HRV was higher (Butner et al., 2017), while no effects for the wife's HRV were observed. The authors suggest that the husband's higher HRV may indicate moments when he makes greater regulatory effort to engage back with the dynamic of the therapist and his wife.

Discussion

The main aim of this study was to carry out a systematic review of the empirical research literature that has included HRV in the study of psychotherapy. In general terms, there is evidence of growing interest in investigating the role of HRV in psychotherapy, particularly in the last five years, which shows its promising value for understanding psychopathological vulnerability, the effectiveness of psychotherapeutic interventions, and therapeutic change associated with the ANS. We found a total of 23 studies meeting the inclusion criteria that we analyzed qualitatively. Most of the studies have been carried out with clinical conditions related to anxious, depressive, and mixed symptoms, which is consistent with the high worldwide prevalence reported for these clinical disorders (World Health Organization, 2022) and the need to develop multifactorial approaches to mental health research and intervention (Bolton, 2013; Fried & Robinaugh, 2020). Thus, the inclusion of HRV in the study of psychotherapy adds a domain of analysis with potential relevance for understanding the etiology of clinical conditions, the effectiveness of treatments, and therapeutic change.

Regarding the methods and designs for obtaining HRV, we found a greater inclination to evaluate the resting HRV before or early in therapy as a psychophysiological parameter with which to contrast psychotherapy outcomes. HRV has also been evaluated at the end of therapy as an outcome variable, along with clinical outcomes. In general terms, almost all studies have followed the recommended guidelines for obtaining and evaluating baseline HRV (e.g., sitting without a demanding cognitive or emotional task), which allows comparability of HRV measures across studies. HRV measurement conditions are very important for making correct inferences about underlying psychophysiological processes (e.g., which physiological system is being assessed such as vagal tone) and their degree of functionality (Laborde et al., 2017; Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). Standard guidelines generally recommend the use of a baseline condition of at least five minutes to assess HRV, which may be less depending on the specific HRV indicator being used (e.g., it is possible to accurately estimate the RMSSD with a one-minute recording; Esco & Flatt, 2014). On the one hand, assessment of baseline HRV is important because it reflects the homeostatic regulatory process rooted in baseline neuron activity firing from brainstem structures to the heart (e.g., nucleus ambiguous neurons projecting to sinoatrial node) without an explicit adaptive effort, since this would imply higher-level limbic and anterior neocortical structures recruitment to respond to environmental demands (Benarroch, 1993; Thayer & Lane, 2009). Baseline HRV also allows comparability

across studies and samples in contrast to the introduction of specific tasks to assess HRV reactivity which makes procedures more heterogeneous, depending on the nature of the task and the conditions of its execution. On the other hand, standard recommendations suggest evaluating HRV reactivity along with baseline HRV since both indicators provide complementary information (Laborde et al., 2017). That is why assessment of baseline HRV must be carried out under standard and well-controlled conditions, and performing a task should involve minimum attentional effort to avoid recruiting other higher- order neurophysiological systems that could obscure the primary vagal activity (Laborde et al., 2017).

In the present review, only three studies included HRV reactivity through different procedures, i.e., a written emotional, engaging task (Steffen et al., 2020), a visual affect matching task (Howells et al., 2014), and a visual, emotional task (Doukas et al., 2014), and only the latter study included a free recovery period. However, the definition of HRV reactivity should consider the difference between two temporally related points (Laborde et al., 2017); without such a contrast, it would be better to use another conceptualization, namely event- or task- related HRV, to avoid conceptual ambiguity. Without a baseline, inferences regarding the functionality of vagal activity are very limited since it is not possible to determine the existence of interactions between baseline HRV and HRV reactivity (Laborde et al., 2017), leaving an incomplete picture of the functionality of vagal activity and the possible existence of undetected subgroups. This last point has an important clinical implication in terms of diagnosis and adjustment of interventions according to patients' therapeutic needs. Additionally, only some of the studies reviewed controlled for variables that may affect cardiac activity, such as pharmacological drug use or the time of day the ECG was obtained. In studies that have assessed vagal reactivity, authors have discussed their findings suggesting that HRV parameters might index patients' psychophysiological resources based on autonomic flexibility to deal with emotional issues that they bring to psychotherapy, informing at an early stage about their potential to benefit from therapy work. Thus, it seems important to pay special attention when both baseline HRV and HRV reactivity are low since patients in this condition might not benefit enough from therapy and might require more specific interventions to meet their psychophysiological potentials and emotional needs. For example, based on their results, Angelovski et al. (2016) suggest that specific moderator mechanisms of psychotherapy for the HRV effect on clinical outcomes might be organismic self-perception and emotion regulation, which could be specific target variables along with HRV to consider in further psychotherapy studies.

Of the total number of studies reviewed, eight included at least one comparison group (without intervention or offering a different kind of intervention): four included a healthy control group without intervention (Caldwell & Steffen, 2018; Carney et al., 2000; Garkani et al., 2009; Howells et al., 2014), one assigned the clinical sample to one of two types of interventions (forest or hospital group) or a control group without intervention (Kim et al., 2009) and three studies assigned the total sample to one of two types of interventions (Angelovski et al., 2016; Lü et al., 2013; Soder et al., 2019). Although the sample sizes tended to be limited (ranging from n = 21 to n = 106), the inclusion of comparison groups allows inferring specific effects of psychotherapeutic interventions beyond the spontaneous remission of symptoms or other nonspecific factors. Interestingly, in this subgroup of studies, all those which assessed HRV before and after treatment revealed therapy-associated psychophysiological changes in a positive direction. Therefore, they add evidence in favor of the rationale that psychotherapeutic interventions strengthen parasympathetic activity over nonspecific factors that can affect autonomic activity. Since other studies have investigated the effects of psychotherapy on other autonomic parameters (Maples-Keller et al., 2019; Marci et al., 2007), this evidence allows the inference that psychotherapy has effects on parasympathetic activity, strengthening patients' psychophysiological resilience. Thus, the study of parasympathetic activity and vagally-mediated HRV throughout psychotherapy is an opportunity to understand long-term outcomes that contribute to mental health and wellbeing, which makes the vagal tone a good candidate for follow-up on the impact of psychological interventions (Wilkie et al., 2022).

However, not all studies found changes in parasympathetic activity across therapy. Seven studies found no variation in resting HRV (Balint et al., 2022; Feldman et al., 2016; Milrod et al., 2016; Neyer et al., 2021; Steffen et al., 2020; Sullivan et al., 2004; Wheeler et al., 2014) and two studies observed a decrease in HRV from pre- to post-therapy (Mathewson et al., 2013; Zimmerman-Viehoff et al., 2016), although in all these studies significant changes in clinical outcomes were observed. These results can be attributed to different scenarios. One possibility is that the inclusion of small or heterogeneous samples and the administration of non-specific therapies for a diversity of symptoms limit the impact of the treatments on psychophysiological activity within the time frames established by these studies.

Such could be the case of the studies by Milrod et al. (2016) and Sullivan et al. (2004) which only included five to eight participants in post-therapy analyses, respectively, or the studies by Neyer et al. (2021) and Wheeler et al. (2014) which included samples with high comorbidity of symptoms. In the case of Steffen et al. (2020), therapy administered in a healthy population could leave less room for positive changes in HRV, a possibility also pointed out by Balint et al. (2022) when referring that psychotherapy might not improve HRV in populations that did not have a reduced HRV. That is, vagal function may already be at or near optimal levels, expressing a large degree of flexibility, so that psychotherapy may not significantly impact its activity. Another possibility stated by Neyer et al. (2021) is that more impaired patients may show gains in psychological functioning after psychotherapy; however, observable changes in HRV activity would require major changes in individuals' behavior.

In some studies, WA was the main process variable linked to patients' HRV (Blanck et al., 2019; Doukas et al., 2014; Stratford et al., 2014). WA is an important common therapy factor that makes a moderate but consistent and significant contribution to change (Flückiger et al., 2018; Lambert & Barley, 2002). The evidence reviewed here indicates that patients' HRV assessed as a pre-treatment patient factor, or an in-session process measure is a direct predictor of WA from the patient's perspective. These findings are consistent with the parasympathetic function attributed to HRV of providing a flexible nervous system-based platform for individuals to display contingent emotional and interpersonal behaviors in a context perceived as trustworthy and safe, as proposed by the polyvagal theory through the concept of neuroception (Porges, 2011). Neuroception is the permanent monitoring carried out by the nervous system of signals of threat or security in the environment outside of consciousness through phylogenetically old brain areas (Porges, 2011). Therapy context may not be "neuroceived" as safe in all cases, e.g., by more vulnerable patients having difficulties in the relational domain (e.g., insecurely attached individuals or in case relational trauma exists), who may require a gradual approach from therapists, particularly in the initial phases of therapy. Although the evidence is still limited, studying HRV as a patient factor related to WA could help differentiate individuals needing a specific approach to develop a favorable therapeutic relationship. On the other hand, HRV as an in-session measure may shed light on session dynamics, revealing possible modes of patient processing of therapy issues beyond the biases of self-reports. Integrating self-report, psychophysiological activity, and observation of non-verbal behavior could favor clarifying the specific processes and mechanisms that underlie work and change in therapy. Also, the study of within-session vagal activity can help disentangle how temporal integration of psychological moments occurs (e.g., in-session events), leading to stable patterns of healthy functioning (Kemp, Koenig, et al., 2017).

Some limitations of the present study should be noted. While qualitative analysis was considered an appropriate strategy because of the dispersion of methodologies and samples included in existing studies, it still has the limitation that it does not allow estimating the magnitude of differences found across investigations at the clinical and psychophysiological levels. Furthermore, the types of interventions implemented differ considerably from each other, which limits comparability between studies. The review did not consider other psychophysiological parameters that have been assessed alongside HRV in some psychotherapy studies, such as heart rate or heart rate variations in domains other than parasympathetic activity (e.g., low-frequency HRV). It would be relevant to consider a joint review of the different psychophysiological parameters in the future to obtain a broader view of the role of autonomic variables in therapy. On the other hand, this review only included studies with adult participants, but HRV measures have also been evaluated in psychotherapy with children (e.g., Bagner et al., 2012). Future studies should consider HRV in different age groups to determine possible consistencies across age groups and specific aspects of each.

Based on the results of this review, the following recommendations may guide planning future studies: the clinical criteria for sample selection, the characteristics of the target population (e.g., depressive, anxious, with mixed symptoms, with/without comorbidity) and the intensity of the symptoms (e.g., mild, moderate, or severe) should be defined rigorously; outcomes should be evaluated with specific instruments that assess symptoms or clinical aspects of the different disorders or conditions; at least one comparison or control group should be included; specific interventions according to a specific psychotherapeutic approach to the problems of the target population should be planned; the level of response to therapy should be considered in the analyses (e.g., by classifying responders and non-responders); the study of vagal activity along with working alliance should be considered to determine a stable pattern of association between the two variables; and other relevant therapy process variables should be taken into account to understand how change occurs (e.g., experiential level or moments of ruptures and

resolutions of ruptures of the WA). In conclusion, the study of HRV related to the process and the results of psychotherapy emerges as a promising index of the potential patients bring to the intervention based on their autonomic resources. According to this review, HRV can be considered in different ways in research: as an early measure that could help identify individuals with greater psychological vulnerability and, thus, allow adjusting the intervention according to their difficulties; and as a measure of change that may be associated or not with other psychological parameters of change. HRV can also be considered an objective measure of the therapeutic process that may complement information from self-report instruments or clinical observations subject to personal biases. Importantly, researchers should adhere to the recommendations mentioned above when planning their studies and designing the protocols for obtaining the HRV in order to gain comparability across research.

Conflicts of interest

The authors have no conflicts of interest to disclose.

References

Aldao, A. (2012). Emotion regulation strategies as transdiagnostic processes: A closer look at the invariance of their form and function. *Journal of Psychopathology and Clinical Psychology*, *17*, 261-277. https://doi.org/10.5944/rppc.vol.17.num.3.2012.11843

Angelovski, A., Sattel, H., Henningsen, P., & Sack, M. (2016). Heart rate variability predicts therapy outcome in pain-predominant multisomatoform disorder. *Journal of Psychosomatic Research*, *83*, 16-21. https://doi.org/10.1016/j.jpsychores.2016.02.003

Austin, M. A., Riniolo, T. C., & Porges, S. W. (2007). Borderline personality disorder and emotion regulation: Insights from the polyvagal theory. *Brain and Cognition*, *65*(1), 69-76. https://doi.org/10.1016/j.bandc.2006.05.007

Bagner, D. M., Graziano, P. A., Jaccard, J., Sheinkopf, S. J., Vohr, B. R., & Lester, B. M. (2012). An initial investigation of baseline respiratory sinus arrhythmia as a moderator of treatment outcome for young children born premature with externalizing behavior problems. *Behavioral Therapy*, *43(3)*, 652-665. https://doi.org/10.1016/j.beth.2011.12.002

Balint, E. M., Daniele, V., Langgartner, D., Reber, S. O., Rothermund, E., Gündel, H., Von Wietersheim, J., Buckley, T., & Jarczok, M. N. (2022). Heart rate variability predicts outcome of short-term psychotherapy at the workplace. *Psychophysiology*, *60*, e14150. https://doi.org/10.1111/psyp.14150

Balzarotti, S., Biassoni, F., Colombo, B., & Ciceri, M. R. (2017). Cardiac vagal control as a marker of emotion regulation in healthy adults: A review. *Biological Psychology*, *130*, 54-66. https://doi.org/10.1016/j.biopsycho.2017.10.008

Beauchaine T. P. (2015). Respiratory sinus arrhythmia: A transdiagnostic biomarker of emotion dysregulation and psychopathology. *Current Opinion in Psychology*, *3*, 43-47. https://doi.org/10.1016/j.copsyc.2015.01.017

Benarroch, E. E. (1993). The central autonomic network: Functional organization, dysfunction, and perspective. *Mayo Clinic Proceedings*, *68*(10), 988-1001. https://doi.org/10.1016/S0025-6196(12)62272-1

Berntson, G. G., Bigger, J. T., Jr., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Haikady, N., Porges, S., Stone, P., & Van der Molen, M., (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, *34*, 623-648. https://doi.org/10.1111/j.1469-8986.1997.tb02140.x

Blanck, P., Stoffel, M., Bents, H., Ditzen, B., & Mander, J. (2019). Heart rate variability in individual psychotherapy: Associations with alliance and outcome. *The Journal of Nervous and Mental Disease*, *207*(6), 451-458. https://doi.org/10.1097/NMD.0000000000000994

Bolton, D. (2013). Should mental disorders be regarded as brain disorders? 21st century mental health sciences and implications for research and training. *World Psychiatry*, *12*(1), 24-25. https://doi.org/10.1002/wps.20004

Brodal, P. (2010). *The central nervous system – Structure and function*. Oxford University Press.

Bulut, N. S., Würz, A., Yorguner Küpeli, N., Çarkaxhıu Bulut, G., & Sungur, M. Z. (2018). Heart rate variability response to affective pictures processed in and outside of conscious awareness: Three consecutive studies on emotional regulation. *International Journal of Psychophysiology*, *129*, 18-30. https://doi.org/10.1016/j.ijpsycho.2018.05.006

Butner, J. E., Deits-Lebehn, C., Crenshaw, A. O., Wiltshire, T. J., Perry, N. S., Kent de Grey, R. G., Hogan, J. N., Smith, T. W., Baucom, K. J. W., & Baucom, B. R. W. (2017). A multivariate dynamic systems model for psychotherapy with more than one client. *Journal of Counseling Psychology*, *64*(6), 616-625. https://doi.org/10.1037/cou0000238

Caldwell, Y. T., & Steffen, P. R. (2018). Adding HRV biofeedback to psychotherapy increases heart rate variability and improves the treatment of major depressive disorder. *International Journal of Psychophysiology*, *131*, 96-101. https://doi.org/10.1016/j.ijpsycho.2018.01.001

Campbell, A. A., Wisco, B. E., Silvia, P. J., & Gay, N. G. (2019). Resting respiratory sinus arrhythmia and posttraumatic stress disorder: A meta-analysis. *Biological Psychology*, *144*, 125-135. https://doi.org/10.1016/j.biopsycho.2019.02.005

Carney, R. M., Freedland, K. E., Stein, P. K., Skala, J. A., Hoffman, P., & Jaffe, A. S. (2000). Change in heart rate and heart rate variability during treatment for depression in patients with coronary heart disease. *Psychosomatic Medicine, 62*(5), 639-647. https://doi.org/10.1097/00006842-200009000-00007

Chalmers, J. A., Quintana, D. S., Abbott, M. J. A, & Kemp, A. H. (2014). Anxiety disorders are associated with reduced heart rate variability: A meta-analysis. *Frontiers in Psychiatry*, *5*, 80. https://doi.org/10.3389/fpsyt.2014.00080

Demaree, H. A., Robinson, J. L., Everhart, D. E., & Schmeichel, B. J. (2004). Resting RSA is associated with natural and self-regulated responses to negative emotional stimuli. *Brain and Cognition*, *56*(1), 14-23. https://doi.org/10.1016/j.bandc.2004.05.001

Doukas, A., D'Andrea, W., Doran, J., & Pole, N. (2014). Psychophysiological predictors of working alliance among treatment-seeking women with complex trauma exposure. *Journal of Traumatic Stress*, *27*(6), 672-679. https://doi.org/10.1002/jts.21968

Dragan, M. (2020). Adverse experiences, emotional regulation difficulties and psychopathology in a sample of young women: Model of associations and results of cluster and discriminant function analysis. *European Journal of Trauma & Dissociation*, *4*(1), 100091. https://doi.org/10.1016/j.ejtd.2018.12.001

Dubey, M., & Sawane, M. (2017). Cardiac autonomic dysfunction assessed by heart rate variability in major depression. *International Journal of Medical Science and Public Health*, *6*(8), 1249-1255. https://doi.org/10.5455/ijmsph.2017.0513221052017

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Esco, M. R., & Flatt, A. A. (2014). Ultra-short-term heart rate variability indexes at rest and post-exercise in athletes: Evaluating the agreement with accepted recommendations. *Journal of Sports Science & Medicine*, *13*(3), 535-541.

Fabes, R. A., & Eisenberg, N. (1997). Regulatory control and adults' stress-related responses to daily life events. *Journal of Personality and Social Psychology*, *73*(5), 1107. https://doi.org/ 10.1037/0022-3514.73.5.1107

Feldman, J. M., Matte, L., Interian, A., Lehrer, P. M., Lu, S. E., Scheckner, B., Steinberg, D. M., Oken, T., Kotay, A., Sinha, S., & Shim, C. (2016). Psychological treatment of comorbid asthma and panic disorder in Latino adults: Results from a randomized controlled trial. *Behaviour Research and Therapy*, *87*, 142-154. https://doi.org/10.1016/j.brat.2016.09.007

Fleury, G., Fortin-Langelier, B., & Ben-Cheikh, I. (2016). The cardiac rhythm of the unconscious in a case of panic disorder. *American Journal of Psychotherapy*, *70*(3), 277-300. https://doi.org/10.1176/appi.psychotherapy.2016.70.3.277

Flückiger, C., Del Re, A. C., Wampold, B. E., & Horvath, A. O. (2018). The alliance in adult psychotherapy: A meta-analytic synthesis. *Psychotherapy*, *55*(4), 316-340. https://doi.org/10.1037/pst0000172

Fredrickson, B. L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological Science*, *13*(2), 172-175. https://doi.org/10.1111/1467-9280.00431

Fried, E. I., & Robinaugh, D. J. (2020). Systems all the way down: Embracing complexity in mental health research. *BMC Medicine*, *18*(1), 1-4. https://doi.org/10.1186/s12916-020-01668-w

Garakani, A., Martinez, J. M., Aaronson, C. J., Voustianiouk, A., Kaufmann, H., & Gorman, J. M. (2009). Effect of medication and psychotherapy on heart rate variability in panic disorder. *Depression and Anxiety*, *26*(3), 251-258. https://doi.org/10.1002/da.20533

Geisler, F. C., Kubiak, T., Siewert, K., & Weber, H. (2013). Cardiac vagal tone is associated with social engagement and self-regulation. *Biological Psychology*, *93*(2), 279-286. https://doi.org/10.1016/j.biopsycho.2013.02.013

Greenberg, L. S., Rice, L. N., & Elliott, R. (1996). *Facilitating emotional change. The moment-by-moment process*. Guilford Press.

Hage, B., Britton, B., Daniels, D., Heilman, K., Porges, S. W., & Halaris, A. (2019). Low cardiac vagal tone index by heart rate variability differentiates bipolar from major depression. *The World Journal of Biological Psychiatry*, *20*(5), 359-367. https://doi.org/10.1080/15622975.2017.1376113

Hartmann, R., Schmidt, F. M., Sander, C., & Hegerl, U. (2019). Heart rate variability as indicator of clinical state in depression. *Frontiers in Psychiatry*, *9*, 735. https://doi.org/10.3389/fpsyt.2018.00735

Heiss, S., Vaschillo, B., Vaschillo, E. G., Timko, C. A., & Hormes, J. M. (2021). Heart rate variability as a biobehavioral marker of diverse psychopathologies: A review and argument for an "ideal range". *Neuroscience & Biobehavioral Reviews*, *121*, 144-155. https://doi.org/10.1016/j.neubiorev.2020.12.004

Houben, M., Van Den Noortgate, W., & Kuppens, P. (2015). The relation between short-term emotion dynamics and psychological well-being: A meta-analysis. *Psychological Bulletin*, *141*(4), 901-930. https://doi.org/10.1037/a0038822

Howells, F. M., Laurie Rauch, H. G., Ives-Deliperi, V. L., Horn, N. R., & Stein, D. J. (2014). Mindfulness based cognitive therapy may improve emotional processing in bipolar disorder: Pilot ERP and HRV study. *Metabolic Brain Disease*, *29*, 367-375. https://doi.org/10.1007/s11011-013-9462-7

Jandackova, V. K., Britton, A., Malik, M., & Steptoe, A. (2016). Heart rate variability and depressive symptoms: A cross-lagged analysis over a 10-year period in the Whitehall II study. *Psychological Medicine*, *46*, 2121-2131. https://doi.org/10.1017/ S003329171600060X

Kemp, A. H., Arias, J. A., & Fisher, Z. (2017). Social ties, health and wellbeing: A literature review and model. In A. Ibáñez, L. Sedeño, & A. M. García (Eds.), *Neuroscience and social science: The missing link* (pp. 397-427). Springer International Publishing/Springer Nature. https://doi.org/10.1007/978-3-319-68421-5_17

Kemp, A. H., Koenig, J., & Thayer, J. F. (2017). From psychological moments to mortality: A multidisciplinary synthesis on heart rate variability spanning the continuum of time. *Neuroscience and Biobehavioral Reviews*, *83*, 547-567. https://doi.org/10.1016/j.neubiorev.2017.09.006

Kemp, A. H., Quintana, D. S., Gray, M. A., Felmingham, K. L., Brown, K., & Gatt, J. M. (2010). Impact of depression and antidepressant treatment on heart rate variability: A review and meta-analysis. *Biological Psychiatry*, *67*(11), 1067-1074. https://doi.org/10.1016/j.biopsych.2009.12.012

Kim, W., Lim, S. K., Chung, E. J., & Woo, J. M. (2009). The effect of cognitive behavior therapy-based psychotherapy applied in a forest environment on physiological changes and remission of major depressive disorder. *Psychiatry Investigation*, *6*(4), 245-254. https://doi.org/10.4306/pi.2009.6.4.245

Koenig, J., Kemp, A. H., Feeling, N. R., Thayer, J. F., & Kaess, M. (2016). Resting state vagal tone in borderline personality disorder: A meta-analysis. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *64*, 18-26. https://doi.org/10.1016/j.pnpbp.2015.07.002

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological Psychology*, *85*(3), 432-436. https://doi.org/10.1016/j.biopsycho.2010.09.005

Kramer, U., Pascual-Leone, A., Despland, J. N., & de Roten, Y. (2015). One minute of grief: Emotional processing in short-term dynamic psychotherapy for adjustment disorder. *Journal of Consulting and Clinical Psychology*, *83*(1), 187-198. https://doi.org/10.1037/a0037979

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart rate variability and cardiac vagal tone in psychophysiological research - Recommendations for experiment planning, data analysis, and data reporting. *Frontiers in Psychology*, *8*, 213. https://doi.org/10.3389/fpsyg.2017.00213

Lambert, M. J., & Barley, D. E. (2002). Research summary on the therapeutic relationship and psychotherapy outcome. In J. C. Norcross (Ed.), *Psychotherapy relationships that work* (pp. 17-32). Oxford University Press.

Lehrer, P. (2013). How does heart rate variability biofeedback work? Resonance, the baroreflex, and other mechanisms. *Biofeedback*, *41*(1), 26-31. https://doi.org/10.5298/1081-5937-41.1.02

Lennartsson, A. K., Jonsdottir, I., & Sjörs, A. (2016). Low heart rate variability in patients with clinical burnout. *International Journal of Psychophysiology*, *110*, 171-178. https://doi.org/10.1016/j.ijpsycho.2016.08.005

Licht, C. M., de Geus, E. J., Zitman, F. G., Hoogendijk, W. J., van Dyck, R., & Penninx, B. W. (2008). Association between major depressive disorder and heart rate variability in the Netherlands Study of Depression and Anxiety (NESDA). *Archives of General Psychiatry*, *65*(12), 1358-1367. https://doi.org/10.1001/archpsyc.65.12.1358

Liddell, B. J., Kemp, A. H., Steel, Z., Nickerson, A., Bryant, R. A., Tam, N., Kuowei, T., & Silove, D. (2016). Heart rate variability and the relationship between trauma exposure age, and psychopathology in a post-conflict setting. *BMC Psychiatry*, *16*, 1-9. https://doi.org/10.1186/s12888-016-0850-5

Lü, W., Wang, Z., & Liu, Y. (2013). A pilot study on changes of cardiac vagal tone in individuals with low trait positive affect: The effect of positive psychotherapy. *International Journal of Psychophysiology*, *88*(2), 213-217. https://doi.org/10.1016/j.ijpsycho.2013.04.012

Maples-Keller, J. L., Rauch, S. A. M., Jovanovic, T., Yasinski, C. W., Goodnight, J. M., Sherrill, A., Black, K., Michopoulos, V., Dunlop, B. W., Rothbaum, B. O., & Norrholm, S. D. (2019). Changes in trauma-potentiated startle, skin conductance, and heart rate within prolonged exposure therapy for PTSD in high and low treatment responders. *Journal of Anxiety Disorders*, *68*, 102147. https://doi.org/10.1016/j.janxdis.2019.102147

Marci, C. D., Ham, J., Moran, E., & Orr, S. P. (2007). Physiologic correlates of perceived therapist empathy and social-emotional process during psychotherapy. *The Journal of Nervous and Mental Disease*, *195*(2), 103-111. https://doi.org /10.1097/01.nmd.0000253731.71025.fc

Mathewson, K. J., Schmidt, L. A., Miskovic, V., Santesso, D. L., Duku, E., McCabe, R. E., Antony, M. M., & Moscovitch, D. A. (2013). Does respiratory sinus arrhythmia (RSA) predict anxiety reduction during cognitive behavioral therapy (CBT) for social anxiety disorder (SAD)? *International Journal of Psychophysiology*, *88*(2), 171-181. https://doi.org/10.1016/j.ijpsycho.2013.03.016

McLaughlin, K. A., Rith-Najarian, L., Dirks, M. A., & Sheridan, M. A. (2015). Low vagal tone magnifies the association between psychosocial stress exposure and internalizing psychopathology in adolescents. *Journal of Clinical Child & Adolescent Psychology*, *44*(2), 314-328. https://doi.org/10.1080/15374416.2013.843464

Milrod, B., Altemus, M., Gross, C., Busch, F., Silver, G., Christos, P., Stieber, J., & Schneier, F. (2016). Adult separation anxiety in treatment nonresponders with anxiety disorders: Delineation of the syndrome and exploration of attachment-based psychotherapy and biomarkers. *Comprehensive Psychiatry*, *66*,139-145.https://doi.org/10.1016/j.comppsych.2016.01.004

Morvaridi, M., Mashhadi, A., Shamloo, Z. S., & Leahy, R. L. (2019). The effectiveness of group emotional schema therapy on emotional regulation and social anxiety symptoms. *International Journal of Cognitive Therapy*, *12*, 16-24. https://doi.org/10.1007/s41811-018-0037-6

Nasso, S., Vanderhasselt, M.-A., Demeyer, I., & De Raedt, R. (2019). Autonomic regulation in response to stress: The influence of anticipatory emotion regulation strategies and trait rumination. *Emotion*, *19*(3), 443-454. https://doi.org/10.1037/emo0000448

Nelson, J., Klumparendt, A., Doebler, P., & Ehring, T. (2020). Everyday emotional dynamics in major depression. *Emotion*, *20*(2), 179-191. https://doi.org/10.1037/emo0000541

Neyer, S., Witthöft, M., Cropley, M., Pawelzik, M., Lugo, R. G., & Sütterlin, S. (2021). Reduction of depressive symptoms during inpatient treatment is not associated with changes in heart rate variability. *PloS One*, *16*(3), e0248686. https://doi.org/10.1371/journal.pone.0248686

Norte, C. E., Souza, G. G. L., Pedrozo, A. L., Mendonça-de-Souza, A. C. F., Figueira, I., Volchan, E., & Ventura, P. R. (2011). Impact of cognitive-behavior therapy on resilience-related neurobiological factors. *Archives of Clinical Psychiatry*, *38*, 43-45. https://doi.org/10.1590/S0101-60832011000100009

Orange, D. M. (1995). *Emotional understanding: Studies in psychoanalytic epistemology*. Guilford Press.

Oveis, C., Cohen, A. B., Gruber, J., Shiota, M. N., Haidt, J., & Keltner, D. (2009). Resting respiratory sinus arrhythmia is associated with tonic positive emotionality. *Emotion*, *9*(2), 265-270. https://doi.org/10.1037/a0015383

Pascual-Leone, A., Paivio, S., & Harrington, S. (2016). Emotion in psychotherapy: An experiential-humanistic perspective. In D. J. Cain, K. Keenan, & S. Rubin (Eds.), *Humanistic psychotherapies: Handbook of research and practice* (pp. 147-181). American Psychological Association. https://doi.org/10.1037/14775-006

Porges, S. W. (2009). The polyvagal theory: New insights into adaptive reactions of the autonomic nervous system. *Cleveland Clinic Journal of Medicine*, *76* (Suppl 2), 86-90. https://doi.org/10.3949/ccjm.76.s2.17

Porges, S.W. (2011). *The polyvagal theory: Neurophysiological foundations of emotions, attachment, communication, and self-regulation*. Norton.

Pu, J., Schmeichel, B. J., & Demaree, H. A. (2010). Cardiac vagal control predicts spontaneous regulation of negative emotional expression and subsequent cognitive performance. *Biological Psychology*, *84*(3), 531-540. https://doi.org/10.1016/j.biopsycho.2009.07.006

Soder, H. E., Wardle, M. C., Schmitz, J. M., Lane, S. D., Green, C., & Vujanovic, A. A. (2019). Baseline resting heart rate variability predicts post-traumatic stress disorder treatment

outcomes in adults with co-occurring substance use disorders and post-traumatic stress. *Psychophysiology*, *56*(8), e13377. https://doi.org/10.1111/psyp.13377

Sperry, S. H., Walsh, M. A., & Kwapil, T. R. (2020). Emotion dynamics concurrently and prospectively predict mood psychopathology. *Journal of Affective Disorders*, *261*, 67-75. https://doi.org/10.1016/j.jad.2019.09.076

Steffen, P. R., Foxx, J., Cattani, K., Alldredge, C., Austin, T., & Burlingame, G. M. (2020). Impact of a 12-week group-based compassion focused therapy intervention on heart rate variability. *Applied Psychophysiology and Biofeedback*, *46*, 61-68. https://doi.org/10.1007/s10484-020-09487-8

Stellar, J. E., Cohen, A., Oveis, C., & Keltner, D. (2015). Affective and physiological responses to the suffering of others: Compassion and vagal activity. *Journal of Personality and Social Psychology*, *108*(4), 572-585. https://doi.org/10.1037/pspi0000010

Stratford, T., Meara, A., & Lal, S. (2014). Heart rate variability and the anxious client: Cardiac autonomic and behavioral associations with therapeutic alliance. *The Journal of Nervous and Mental Disease*, *202*(8), 613-619. https://doi.org/10.1097/NMD.0000000000000163

Sullivan, G. M., Kent, J. M., Kleber, M., Martinez, J. M., Yeragani, V. K., & Gorman, J. M. (2004). Effects of hyperventilation on heart rate and QT variability in panic disorder pre- and post-treatment. *Psychiatry Research*, *125*(1), 29-39. https://doi.org/10.1016/j.psychres.2003.10.002

Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Circulation*, *93*, 1043-1065. https://doi.org/10.1161/01.CIR.93.5.1043

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). 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), 747-756. https://doi.org/10.1016/j.neubiorev.2011.11.009

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*(3), 201-216. https://doi.org/10.1016/S0165-0327(00)00338-4

Thayer, J. F., & Lane, R. D. (2009). Claude Bernard and the heart-brain connection: Further elaboration of a model of neurovisceral integration. *Neuroscience & Biobehavioral Reviews*, *33*(2), 81-88. https://doi.org/10.1016/j.neubiorev.2008.08.004

Wekenborg, M. K., Hill, L. K., Thayer, J. F., Penz, M., Wittling, R. A., & Kirschbaum, C. (2019). The longitudinal association of reduced vagal tone with burnout. *Psychosomatic Medicine*, *81*(9),791-798.https://doi.org/10.1097/PSY.0000000000000750

Wheeler, A., Denson, L., Neil, C., Tucker, G., Kenny, M., Beltrame, J. F., Schrader, G., & Proeve, M. (2014). Investigating the effect of mindfulness training on heart rate variability in mental health outpatients: A pilot study. *Behaviour Change*, *31*(3), 175-188. https://doi.org/10.1017/bec.2014.14

Wilkie, L., Fisher, Z., & Kemp, A. H. (2022). The complex construct of wellbeing and the role of vagal function. *Frontiers in Integrative Neuroscience*, *16*, 925664. https://doi.org/10.3389/fnint.2022.925664

World Health Organization (2022). *Mental disorders*. https://www.who.int/news-room/fact-sheets/detail/mental-disorders

Yeh, T. C., Kao, L. C., Tzeng, N. S., Kuo, T. B., Huang, S. Y., Chang, C. C., & Chang, H. A. (2016). Heart rate variability in major depressive disorder and after antidepressant treatment with agomelatine and paroxetine: Findings from the Taiwan Study of Depression and Anxiety (TAISDA). *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *64*, 60-67. https://doi.org/10.1016/j.pnpbp.2015.07.007

Zimmermann-Viehoff, F., Thayer, J., Bergt, J., Weber, C. S., Erdur, L., Richter, S., & Deter, H. C. (2016). Heart rate variability during inpatient psychosomatic treatment - A naturalistic observational study. *Zeitschrift für Psychosomatische Medizin und Psychotherapie*, *62*(1), 20-31. https://doi.org/10.13109/zptm.2016.62.1.20