

Implicit Measures of Extreme Psychological Distress in Young Healthy Adults: Cardiac Autonomic Activity and Attentional Bias

Ada H. Zohar^{1,2*} , Yossi Levi-Belz^{1,2} , Marian Linetzky^{1,3} 

¹Graduate Program in Clinical Psychology, Ruppin Academic Center, Emek Hefer, Israel

²Lior Tsfaty Center for Suicide and Mental Pain studies, Ruppin Academic Center, Emek Hefer, Israel

³School of Psychological Sciences, Tel Aviv University, Tel Aviv, Israel

Email: *AdaZ@ruppin.ac.il

How to cite this paper: Zohar, A. H., Levi-Belz, Y., & Linetzky, M. (2023). Implicit Measures of Extreme Psychological Distress in Young Healthy Adults: Cardiac Autonomic Activity and Attentional Bias. *Psychology, 14*, 1712-1727.
<https://doi.org/10.4236/psych.2023.1411100>

Received: September 20, 2023

Accepted: November 20, 2023

Published: November 23, 2023

Copyright © 2023 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Background: There is research showing that cardiac sympathetic autonomic activity is elevated and cardiac parasympathetic autonomous activity is decreased in individuals contending with serious psychopathology. There is also work showing that attentional bias to emotionally distressing stimuli is affected by depression and anxiety. This study hypothesized that individuals who were high on suicide-related attention bias (AB) and cardiac sympathetic activity (SNS index) would also have elevated psychological distress, even in the absence of a diagnosable disorder. **Methods:** Participants were 181 healthy college students, 42.5% male. Personality traits, depression, hopelessness and suicidal ideation/behaviour were self-reported. Cardiac activity was measured using bodyguard2, and the SNS index was used as a measure of stress. AB was measured using stimuli salient in the context of death and suicide. **Results:** Correlations were in the expected direction. Cluster analysis using AB and the SNS index produced three clusters, of which Cluster 3, 19.7% of the sample, had elevated AB and SNS index, and by far the most distressed psychological profile, above the clinical cut-off point for depression. **Conclusions:** The study results indicate a strong association between objective and subjective measures of distress uncovered by cluster analysis. Such result may help to identifying a group of extremely distressed individuals among healthy adults. Individuals with a distressed personality profile, who are depressed and reject life, can be distinguished by their cardiac stress and AB.

Keywords

HRV, Personality, SNS Index, Attention Bias, Psychological Distress

1. Introduction

Psychological distress includes symptoms of depression and anxiety and a lessened sense of well-being, which affect the individual's functioning. At the extremes, psychological distress can precede the outbreak of diagnosable psychiatric disorders, such as mood (Cairney & Krause, 2005) or anxiety disorders (Cloninger et al., 2012), or even lead to suicidal ideation, suicidal behavior, or to completed suicide (Wu et al., 2020).

Psychological distress is fairly common. A decade before the outbreak of COVID-19, the National Institute of Mental Health (the National Institute of Mental Health, 2012) estimated that about 20% of the American public experienced significant psychological distress. A decade later, during the COVID-19 epidemic, a meta-analysis showed that in many countries, the prevalence of significant psychological distress encompassed about 40% of the population (Necho et al., 2021). There is also evidence, that the psychological distress experienced by the general public was especially significant in young adults, for whom lockdown and social isolation were particularly stressful (Glowacz & Schmits, 2020).

The level of psychological distress an individual experiences is affected by the occurrence of internal and external stressors and thus is variable over time. However, the individual's personality exercises a continued influence on the individual's stress resistance. Asselmann et al., (Asselmann et al., 2020) found that women higher in conscientiousness and in extraversion developed less psychological distress over the normative stress of pregnancy and childbirth. Sumin, Prokashko, and Shcheglova, (Sumin et al., 2022) found that students with Type D or distressed personality (Denollet, 2005), i.e. high negative affectivity and social inhibition, coped less effectively with the stress induced by medical school, and experienced more psychological distress. Cloninger and Zohar et al., (Cloninger & Zohar, 2011), found that individuals who are more harm avoidant, i.e. pessimistic, afraid of uncertainty, shy and fatigable, and lower in self-directedness, i.e., less able to act responsibly, in a goal-oriented and responsible fashion, were more prone to psychological distress.

Cardiac activity has been tied to personality. Koelsch Enge and Jentschke (Koelsch et al., 2012), found that resting HRV correlated positively with positive emotion and agreeableness, and negatively with neuroticism. Zohar et al., (Zohar et al., 2013) measured heart activity over 24 hours and found that a summary measure of HRV was positively predicted by the character traits of self-directedness, cooperativeness and self-transcendence, the components of mature personality that make it possible for individuals to pursue their personal goals, work with others, and strive for the greater good (Cloninger 2004). These same traits also contribute to individuals' happiness and health (Cloninger & Zohar, 2011).

Cardiac activity is also associated with psychological distress, HRV was a physiological moderator between race-related stress and psychological distress in African-American men (Utsey & Hook, 2007). Föhr et al., (Föhr et al., 2015), found that workers who reported more stress and psychological distress exhi-

bited less HRV than others. Brugnera et al., (Brugnera et al., 2017), in a controlled randomized experiment, found that the experimentally stressed group reported more psychological distress than the control group, and also showed lower HRV. Extreme psychological distress, i.e. individuals who are experiencing suicidal ideation or have actually engaged in suicidal behavior, show lower overall HRV (Méndez et al., 2013) less parasympathetic (PNS) inhibitory activity (Adolph et al., 2018) and increased sympathetic (SNS) excitatory activity (Wilson et al., 2016). The combination of reduced PNS activity and increased SNS activity indicates more cardiac stress (Baevsky & Karnikova, 2017). The reverse is also true; Jelinek, and Khandoker, (Jelinek & Khandoker, 2020) found that by using biofeedback to raise PNS activity and lower SNS activity suicidal ideation was reduced in adolescent patients.

Attention bias is the tendency to allocate attention resources toward specific, usually emotion-provoking stimuli in the environment (Azriel & Bar-Haim, 2020). Empirical evidence has established a link between various emotional states, such as anxiety and depression, and attentional biases (Linetzky et al., 2015; Elgersma et al., 2018). An attentional bias might also be evident in individuals contemplating suicide (Lin et al., 2022). This is especially important since these individuals may dissimulate or fail to self-disclose their status, thus increasing their psychological distress levels (Levi-Belz et al., 2014; Levi-Belz et al., 2019). There is some evidence supporting this notion. Cha et al., (Cha et al., 2010) administered a modified emotional Stroop task, comprised of suicide-related and neutral words, in patients seeking emergency psychiatric help. They found that suicide attempters showed an attentional bias toward suicide-related words relative to neutral words, and this bias was strongest among those who had made a more recent suicide attempt (Cha et al., 2010). Moreover, this suicide-related attention bias added explained variance in predicting suicidal behavior over a 6-month follow-up, even after controlling for commonly used clinical predictors. Thompson and Ong (Thompson & Ong, 2018) applied an emotional Stroop test to female college students classified as high versus low suicide-risk groups. They found that the high-risk group displayed slower reaction times overall, particularly when the stimulus word “suicide” was presented (Thompson & Ong, 2018).

Several paradigms are commonly used to measure attentional biases. One of which is the dot probe task, in which two competing stimuli are presented and response time is used as an indicator of participants’ attention allocation (MacLeod et al., 1986). This objective measure of attention bias, consisting of suicide-related, as well as neutral stimuli, is utilized in the present study.

The present study

While cardiac activity, attentional bias and personally traits were all found to be related to psychological distress, suicide risk and suicide tendencies, no study to date has examined their combined contribution as predictors of increased psychological distress. In this study, we explored the relationship between implicit and explicit, objective and subjective measures of distress. The hypothesis of

this study was that the objective measures, suicide-related attentional bias and SNS index would discriminate between individuals who were more psychologically distressed than others.

2. Methods and Materials

2.1. Procedure

The original plan was to conduct the study in the laboratory. However, the outbreak of the COVID-19 pandemic and the concern for the health of the experimenters and participants, as well as the restrictions mandated by the pandemic, led us to redesign the study so that it could be conducted remotely. This included programming the dot-probe attentional bias task so that it could be administered remotely and changing the stationary lab measurement of HRV to using a heart monitor with a rechargeable battery which is designed for ambulatory measurement, and was delivered to the participants. The revised plan gained ethical approval according to the Helsinki guidelines (2020-46 L/cp) by the institutional review board of Ruppin Academic Center (see appended). Potential participants responded to an online notice, contacted the research team and set a date for the home delivery of the heart activity monitor and for conducting the experiment. All participants signed informed consent online. The participants were carefully instructed on how to connect the monitor. First-year psychology students received academic credit for their participation and the other participants were given a gift voucher for their participation.

2.2. Participants

Participants were 181 healthy adults, ranging in age between 19 and 43 with a mean of 25.4 ± 3.3 . 95 participants were recruited from several colleges and university campuses by social media and word of mouth, and the remainder were undergraduates enrolled in an introductory psychology class. 42.5% ($n = 77$) of the sample were male. Their BMI (calculated from self-reported height and weight) ranged from 17.7 to 33.6 with a mean of 23 ± 2.9 . Their years of schooling ranged between 12 and 19, with a mean of 13 ± 1.5 . A known heart condition was grounds for exclusion.

2.3. Objective Measures

Heart Activity

Heart activity was measured using a bodyguard2© tracking device with a rechargeable battery. Well-suited to ambulatory measurement it weighs only 24 g and connects to the chest with two light disposable electrodes. Measurement is reliable over a wide range of temperatures (+5 - +50 C degrees), According to the manufacturers' specifications, heart rate accuracy is 1 ms (1000 Hz) and sampling frequency is 1.56 Hz - 200 Hz. Recordings lasted at least 3 hours and were downloaded from the monitors as SDF files. Analyses of 5 minutes at rest and one hour of normal ambulatory activity produced the HRV variables for the

study. Analyses were conducted in Standard Kubios with beat correction set at a very low (0.3) threshold. All recordings that were used required less than 1% beat correction.

The following measures of HRV were included in the analyses:

SNS index—a measure of sympathetic vagal excitation that increases heart rate and decreases HRV, and is evident in the low-frequency signals. Mean heart rate, the Baevsky (Baevsky, 2008) stress index, and the Poincare SD2 plot index are used to calculate the SNS index. All three components are reduced to standard deviation units using population norms (Nunan et al., 2010).

PNS index—a measure of parasympathetic vagal inhibition, which slows heart rate and increases HRV, and is evident in the high-frequency signals. Its calculation rests on the mean R-to-R interval, the square root of the successive R-to-R intervals (RMSDD), and the Poincare plot index SD1. The PNS index is given in units of standard deviations relative to age-adjusted norms of healthy individuals (Nunan et al., 2010; Shaffer & Ginsberg, 2017).

The PNS and SNS indexes provide reliable estimates of the autonomic nervous system activities (Sahoo, et al., 2019).

The Stress Index (SI)—is calculated in Kubios using the Baevsky (Baevsky, 2008) formula, taking its square root so the distribution is less skewed (Sahoo, et al., 2019). SI is a geometric measure of HRV reflecting cardiovascular system stress. High values of SI indicate reduced variability and high sympathetic cardiac activation.

2.4. Attention Bias

Suicide-Related Attentional Bias was measured using a dot-probe task (Azriel & Bar-Haim, 2020). In this task, participants are asked to respond to a target probe that appears in one of the locations previously occupied by two briefly presented word stimuli: one neutral word and one word related to suicide/death. Probes appear with equal probability at the neutral and suicide words' locations. Each trial begins with a central fixation cross (500 ms), followed by a pair of words (500 ms). The probe consists of an arrowhead pointing either left or right (“<” or “>”) appearing at the location previously occupied by one of the words until response. Words are presented in size 12 Arial white font over a black background, one above and one below the location of the fixation cross, separated by 1.5 cm.

Each trial is followed by an inter-trial interval (500 ms). Suicide word location, probe location, and probe type are fully counterbalanced in the presentation. Participants are instructed to respond as quickly as possible without compromising accuracy. Each measure consists of 160 trials, 128 trials contain one neutral word and one suicide word, and 32 filler trials contain two neutral words. A 30-second break is provided after 80 trials. Attention bias toward suicide-related words was calculated by subtracting the mean reaction time of trials in which the probe appeared behind suicide/death words from the mean reaction time of trials in which the probe appeared behind neutral words. Positive values reflect an attention bias towards suicide-related stimuli whereas negative values reflect at-

tention bias away from suicide-related stimuli.

2.5. Psychological Measures

The temperament and character inventory (TCI; Zohar & Cloninger, 2011), was used to measure Harm Avoidance (HA) and Self-Directedness (SD). HA is a temperamental inhibitory tendency measured by 20 items such as “I often feel tense and worried in unfamiliar situations, even when others see no cause for worry”; SD is a self-organizing character trait measured by 20 items such as “Often I feel that my life has purpose and meaning.” In the current study, the scales had high internal reliability, $\alpha = 0.92$ for HA and $\alpha = 0.88$ for SD.

An additional measure of personality used in this study was the **DS14**, a measure of distressed personality (Denollet, 2005) in its Hebrew translation (Zohar et al., 2011). The DS14 has 14 items, 7 for each of two traits. Negative affectivity (NA) includes worry, irritability and dysphoria, as in “I am often down in the dumps” and SI discomfort, reticence, and awkwardness in social situations as in “When socializing, I don’t find the right things to talk about”. Each item is answered on a 4-category scale from 0 to 4. A measure of the Type D personality tendency is derived from the product of the scores on both subscales (Zohar, 2016). In the current study, the scale reliabilities were $\alpha = 0.86$ for NA and $\alpha = 0.89$ for SI.

Depression. Depression levels were assessed by the Patient Health Questionnaire Depression Scale (PHQ-9; Kroenke et al., 2001), which is a 9-item depression screen used to assess depressive symptoms. Participants are asked, “Over the last 2 weeks, how often have you been bothered by any of the following problems?” They then rate each of these symptoms on a 4-point scale, ranging from 0 (*not at all*), 1 (*several days*), 2 (*more than half the days*) to 3 (*nearly every day*). The PHQ-9 score is associated with increased use of medical facilities, physical disability, risk of psychiatric comorbidity, and overall syndromic severity. The reliability of the scale in the current study was $\alpha = 0.86$. A cutoff point for clinical depression is above 8 (Manea et al., 2012).

Hopelessness. The Beck Hopelessness Scale (BHS; Beck, et al., 1974) contains 20 items. The sum of the scores on the individual items yields a total hopelessness score ranging from 0 to 20. In the current study, the internal reliability was $\alpha = 0.82$.

Suicide tendencies. The multi-attitude suicide tendency (MAST; Orbach et al., 1991) scale is a 30-item self-report measure of attitudes toward life and death. Unlike most traditional assessment inventories, the MAST is designed to assess conflicting attitudes related to adolescent and adult suicidality. The four types of conflicting attitudes identified by Orbach et al. (Orbach et al., 1991) are Attraction to Life and Repulsion by Life; Attraction to Death and Repulsion by Death. In the current study, we included the first two scales as those differentiate suicidal from non-suicidal individuals (Osman et al., 1993). Attraction to Life had internal reliability of $\alpha = 0.86$ in the current study; while Repulsion by Life had internal reliability of $\alpha = 0.81$.

Suicide risk. The Suicidal Behaviors Questionnaire-Revised (SBQ-R; Osman et al., 2001) was used to assess suicide risk of the participants. The SBQ-R meas-

ures suicidal ideation and/or previous suicide attempts, frequency of suicidal ideation over the past 12 months, current threat of making a suicide attempt, and likelihood of suicidal behavior in the future. We chose the SBQ-R over other inventories because it taps both suicide ideation and behavior in a short and validated questionnaire. The SBQ-R total score has good internal reliability ($\alpha = 0.88$) and evidence for clinical utility i.e. the ability to differentiate between suicidal and non-suicidal subgroups in both clinical and nonclinical samples (Osman et al., 2001).

3. Results

3.1. Descriptive Statistics

Table 1 shows the correlations between the study variables as well as their means and standard deviations.

As can be seen in **Table 1** above, the signs of the correlations are as expected, and some are significant. The HRV variables of PNS, SNS and the stress index were significantly correlated with harm avoidance, and Type D personality. Type D personality was also significantly correlated with the Stress index. Interestingly, the Stress index was also significantly correlated with the self-report measures of depression, hopelessness as well as positively correlated with repulsion by life and negatively correlated with attraction to life. Attentional bias correlated positively and significantly with Type D personality. Suicide risk was not correlated with any of the objective measures. To further investigate the relationship between the psychological distress variables and the objective measures cluster analysis was performed.

Table 1. Correlations, means and standard deviations of study variables (n = 181).

	Attention Bias	PNS index	SNS index	Stress index	Mean (SD)
Harm Avoidance	0.045	-0.227**	0.221**	0.201**	56.65 (14.0)
Self-Directedness	-0.084	0.163*	-0.147	-0.144	69.72 (11.3)
Type D personality	0.161*	-0.160*	0.143	0.177*	121.14 (139.3)
Depression	0.111	-0.117	0.137	0.176*	6.68 (4.9)
Hopelessness	0.023	-0.122	0.079	0.164*	2.45 (3.0)
Attraction to Life	0.044	0.091	-0.068	-0.147*	33.97 (4.3)
Repulsion by Life	0.027	-0.093	0.090	0.175*	12.26 (4.2)
Suicide risk	0.038	-0.010	-0.018	0.036	4.09 (1.5)
Mean (SD)	-1.21 (22.7)	-0.43 (1.1)	0.46 (1.1)	6.95 (1.9)	

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). Type D personality is measured by the product of the NA and the SI scores.

3.2. Cluster Analysis

The hypothesis of this study was that the objective measures, suicide-related at-

tention bias and SNS index would discriminate between individuals in extreme psychological distress and others.

To test this hypothesis, we conducted two-step cluster analysis. The SPSS command capped the number of clusters at 4 and used two variables for creating the clusters: Attention Bias (AB) i.e., attentional bias toward suicide and death, and the SNS index, i.e. the degree of sympathetic arousal of heart activity.

The 3-cluster solution had fair cohesion and separation. Both predictor variables contributed to the clustering process. Cluster 1 included 37.6% of the participants, Cluster 2 included 42.7% of the participants, and Cluster 3 was smaller than the first two, with 19.7% of the participants, making the ratio between the smallest and biggest cluster 2.17, below the recommended maximum of 3. The standardized values of the objective measures of the 3 clusters are shown in **Figure 1** below.

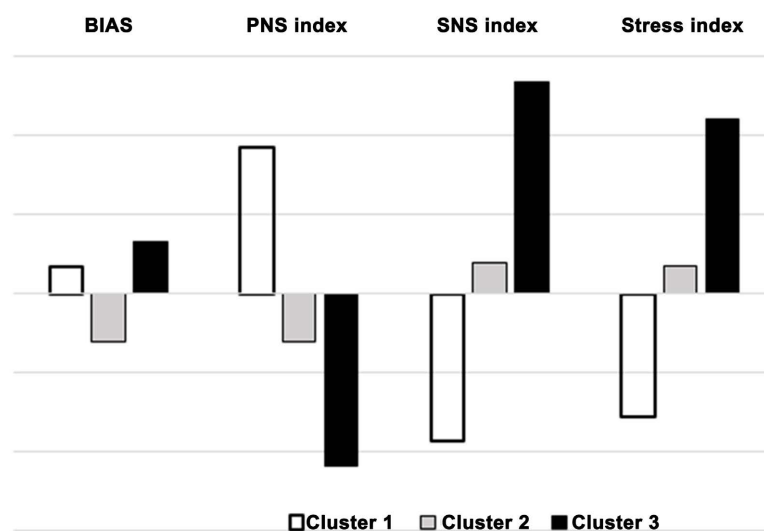


Figure 1. Objective measures for the three clusters.

For the objective measures, Cluster 2 has average values. Cluster 1 and 3 are both different from Cluster 2. Both Cluster 1 and 3 have elevated AB relative to Cluster 2, but otherwise are mirror images of each other, with Cluster 1 showing high PNS activity, low SNS activity and low-stress index, and Cluster 3 showing cardiac stress, with high SNS index, low PNS index, and high-stress index.

The three clusters identified for their SNS index and AB were then compared for their psychological characteristics. **Figure 2** below shows the means of the standardized psychological variables. As can be seen in **Figure 2** below, the Cluster 2 group fairs well for all the psychological measures of distress, echoing their favorable values for AB and the SNS index. Cluster 1 fares a little worse than Cluster 2, and is higher for most of the distress variables. The dramatic differences are for Cluster 3 individuals, who score highest on all the distress measures.

Although the clustering process rested solely on the objective measures, it is clear from **Figure 2** that the clusters are very different in their psychological profile. Cluster 1 and Cluster 2 are fairly similar, although Cluster 2 individuals

are higher for the protective variables, Self-Directedness and Attraction to Life, and lower on all the risk variables. Cluster 3 is dramatically different from both with the most intensely distressed profile.

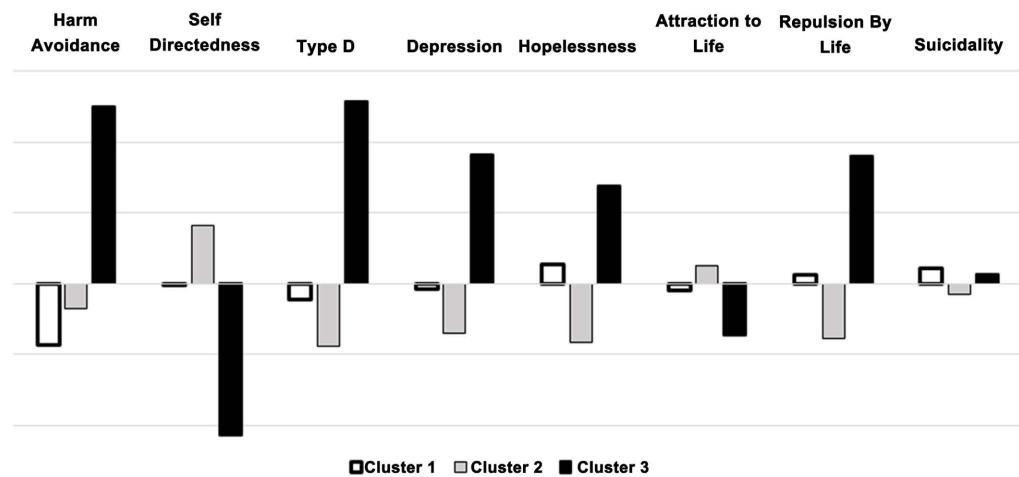


Figure 2. Psychological Profile of the three clusters (presented in SD units).

In order to examine the statistical differences in the study measures as a function of the different clusters, we conducted analysis of variance using the clusters as the factor and comparing the three clusters using post-hoc group comparisons with the Sheffe range correction. In **Table 2** below, the means of the variables for the 3 groups identified by cluster analysis are presented, as well as the test of the group differences. The three clusters are different for all the psychological variables other than suicidality, Attraction to Life, and hopelessness. However, the order is preserved even for these variables in the sense that Cluster 3 is the most distressed.

Table 2. Analysis of variance for study variables for the three clusters.

	Cluster 1 Mean (SD)	Cluster 2 Mean (SD)	Cluster 3 Mean (SD)	F (p)	Cluster Differences*
Harm Avoidance	54.25 (14.1)	55.68 (13.6)	63.63 (13.1)	5.78 (0.004)	1 < 3, 2 < 3
Self-Directedness	69.69 (12.2)	71.57 (10.4)	64.91 (9.9)	4.38 (0.014)	2 > 3
Type D personality	114.87 (151.2)	96.80 (104.3)	193.11 (163.9)	6.18 (0.003)	1 < 3, 2 < 3
Depression	6.61 (5.9)	6.00 (4.1)	8.49 (4.4)	3.11 (0.047)	1 < 3
Hopelessness	2.61 (3.6)	1.96 (2.4)	3.29 (2.9)	2.48 (0.087)	
Attraction to Life	33.88 (5.2)	34.18 (3.7)	33.90 (3.6)	0.46 (0.63)	
Repulsion by Life	12.37 (4.7)	11.62 (3.4)	13.77 (4.3)	3.27 (0.04)	2 < 3
Suicidality	4.16 (1.6)	4.05 (1.6)	4.14 (1.2)	0.105 (0.90)	
Attention Bias	2.73 (17.2)	-8.12 (13.8)	6.31 (39.1)	6.77 (0.001)	1 > 2, 3 > 2, 3 > 1
PNS index	0.59 (0.88)	-0.76 (0.54)	-1.63 (0.65)	128.11 (0.000)	1 > 2, 1 > 3, 2 > 3
SNS index	-0.56 (0.55)	0.68 (0.48)	1.94 (0.91)	203.66 (0.000)	1 < 2, 1 < 3, 2 < 3
Stress Index	5.43 (1.1)	7.29 (1.5)	9.09 (1.7)	80.41 (0.000)	1 < 2, 1 < 3, 2 < 3

*Post-hoc Cluster comparisons with Sheffe range correction.

The table shows that the three clusters are significantly different for most of the psychological variables. In particular, Cluster 3's mean depression score is above the clinical cutoff point identified by Manea et al., (Manea et al., 2012). Their Type D score is above the cutoff score suggested by Zohar (Zohar, 2016). They are more harm-avoidant and less self-directed. Their repulsion from life score is highest, as is their hopelessness score, although the difference between the three clusters is not statistically different. In summary, Cluster 3 individuals show significant psychological distress.

4. Discussion

In this study, we sampled healthy college students living through a stressful period caused by the COVID-19 epidemic. These individuals were high-functioning, in that they managed to get through their academic courses at a time of uncertainty, isolation and distance learning. It is thus not surprising that we found low levels of suicidal ideation and suicide risk among the participants. However, the participants could be characterized as experiencing different levels of distress, reflected by their levels of depression, hopelessness, and repulsion by life.

In addition, we measured personality traits, that have a chronic influence on distress and stress proneness. We measured Type D or distressed personality (Denollet, 2005), a stable personality configuration, that combines negative affectivity and social inhibition; Type D personality is associated with poor health, psychopathology, and suicidality (Denollet et al., 2021). We also measured Harm Avoidance (HA), an inhibitory temperament trait that is characterized by pessimism, shyness, anxiety, and fatigability, and Self Directedness (SD), a protective character trait that enables individuals to behave responsibly, in a goal-oriented fashion, to initiate and improvise, and thus further their personal goals (Cloninger, 2004). Low SD and high HA are associated with ill health and low subjective well-being (Cloninger & Zohar, 2011) as well as with anxiety and mood disorders (Cloninger et al., 2012).

The correlations between the objective measures and the psychological distress found in the current study were in the expected direction, as found in previous research (Zohar et al., 2013; Miranda et al., 2021). We found an association between suicide-related attentional bias and cardiac stress and psychological distress.

Cluster analysis, an approach for classifying groups of individuals according to their scores on key variables, was used to try and uncover meaningful associations between the implicit measures and psychological distress. The key variables used were suicide-related attentional bias (AB) and sympathetic autonomic (SNS) heart activity, both hypothesized to be elevated in distressed individuals. The analysis produced three distinct clusters. Cluster 1, which included 37.6% of the participants, had elevated AB but low SNS index. Cluster 2 which included 42.7% of the participants, was best for the objective measures, having the lowest AB and the lowest SNS index. Cluster 3 which included 19.7% of the partici-

pants, was highest in AB and also highest in SNS index, indicating by the objective measures the most vulnerable group of participants. The vulnerability of Cluster 3 individuals for psychological distress versus the other two clusters was dramatic and significant, as the analysis of variance uncovered. Cluster 3 individuals were highest in Harm Avoidance and Type D personality, and lowest in Self-Directedness, thus their personality profile was that of enduring chronic distress. In addition, they were elevated for symptoms of depression and for Repulsion by Life.

To what extent were Cluster 3 individuals distressed? Their mean depression level was above the clinical cutoff score suggested by Manea et al., (Manea et al., 2012). Their Type D personality score indicated a stable distressed personality configuration (Zohar, 2016). Thus, they were not only more distressed than the individuals in Clusters 1 and 2, they screened as depressed.

Interestingly, we found that the most psychologically distressed individuals had elevated SNS activity, and lowered PNS activity, leading to cardiac stress. Such results are important as they connect psychological distress to objective cardiac measures. Such results are in line with several previous studies. For example, Rüesch et al., (Rüesch et al., 2022) found that they could distinguish psychiatric inpatients with a recent suicidal attempt from others by their elevated SNS activity and lowered PNS activity. Sheridan et al., (Sheridan et al., 2021), found that severely suicidal adolescents had lowered PNS activity that could be detected by wearable devices, and suggested monitoring suicidal patients for PNS activity in order to protect them from suicidal behavior. In their review, MaCall et al., (MaCall et al., 2022) summarized the evidence for autonomic cardiac hyper-arousal in suicidal individuals, and suggested adding HRV measurements to the assessment of suicidality in psychiatric intake. Our results suggest that modifying both attentional bias and cardiac hyper-arousal for distressed individuals may be helpful and inexpensive interventions for those who are experiencing acute psychological distress.

These findings should be interpreted in light of the study's limitations. The participants of this study were healthy college students, who were managing to study during the COVID-19, 2020-2022, thus high functioning. As a whole they were not suicidal, although they varied in their depressive symptoms, and in their Repulsion by Life; It is thus surprising that their distressed status could be detected to a certain degree by their attentional bias and their cardiac hyper-arousal, as found for suicidal psychiatric in-patients. Because the data gathered in this correlational study was cross-sectional, the research design precludes us from drawing any causal inference regarding the relations among variables. It is clear that the study results are preliminary, and prospective longitudinal studies are needed in order to infer causality. Furthermore, the data regarding psychological distress was obtained using self-report, which can introduce biases caused by factors such as mood-dependent recall, forgetting, cathartic effect, and social desirability. Future studies should consider using observa-

tional measures for distress, such as quantitative observation of behavior.

Despite these limitations, this study represents a modest step forward in the role of objective markers in identifying psychological distress in healthy adults. More importantly, our study results show that a combination of objective measures may be used in such early identification. It is plausible that a specific set of objective measures can serve as significant predictors or signals of psychological distress, especially for those who have difficulties in sharing their distress (e.g. Levi-Belz et al., 2019) and can help us to detect and intervene in a timely manner (Barredo et al., 2021).

Acknowledgements

The authors wish to acknowledge the support of the Ruppin Academic Center and the Lior Zfaty Suicide and Mental Pain Research Center grant 33502.

The authors thank the research assistants, whose dedication, tenacity, and creativity, made the execution of this study possible under restrictions of personal distancing and travel limitations due to the pandemic.

And above all, we wish to thank the participants in this study, all undergraduate or graduate students, struggling to maintain their academic performance under pandemic conditions, who invested time and energy in their participation.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The authors will share the data with those interested upon request. Requests should be addressed to the corresponding author at adaz@ruppin.ac.il.

Author Contributions

AHZ conceptualized the research design, oversaw the data collection, curated the data, conducted the formal analyses, and wrote the manuscript. YLB contributed to research design, acquired the funding for the project, and was active in the reviewing and editing of the manuscript. ML took the lead in building the attentional bias measure and performed the analyses of the data that the measure produced as well as commenting on the manuscript.

References

- Adolph, D., Teismann, T., Forkmann, T., Wannemüller, A., & Margraf, J. (2018). High Frequency Heart Rate Variability: Evidence for a Transdiagnostic Association with Suicide Ideation. *Biological Psychology*, *138*, 165-171. <https://doi.org/10.1016/j.biopsycho.2018.09.006>
- Asselmann, E., Kunas, S. L., Wittchen, H. U., & Martini, J. (2020). Maternal Personality, Social Support, and Changes in Depressive, Anxiety, and Stress Symptoms during Pregnancy and after Delivery: A Prospective-Longitudinal Study. *PLOS ONE*, *15*, e0237609. <https://doi.org/10.1371/journal.pone.0237609>

- Azriel, O., & Bar-Haim, Y. (2020). Attention Bias. In J. S. Abramowitz, & S. M. Blakey (Eds.), *Clinical Handbook of Fear and Anxiety: Maintenance Processes and Treatment Mechanisms* (pp. 203-218). American Psychological Association.
<https://doi.org/10.1037/0000150-012>
- Baevsky, R. M. (2008). Methodical Recommendations Use Kardivar System for Determination of the Stress Level and Estimation of the Body Adaptability Standards of Measurements and Physiological Interpretation.
- Baevsky, R. M., & Chernikova, A. G. (2017). Heart Rate Variability Analysis: Physiological Foundations and Main Methods. *Cardiometry, 10*, 66-76.
<https://doi.org/10.12710/cardiometry.2017.10.6676>
- Barredo, J., Bozzay, M. L., Primack, J. M., Schatten, H. T., Armev, M. F., Carpenter, L. L., & Philip, N. S. (2021). Translating Interventional Neuroscience to Suicide: It's about Time. *Biological Psychiatry, 89*, 1073-1083.
<https://doi.org/10.1016/j.biopsych.2021.01.013>
- Beck, A., Weissman, A., Lester, D., & Trexler, L. (1974). The Measurement of Pessimism: The Hopelessness Scale. *Journal of Consulting and Clinical Psychology, 4*, 861-865.
<https://doi.org/10.1037/h0037562>
- Brugnera, A., Zarbo, C., Adorni, R., Tasca, G. A., Rabboni, M., Bondi, E., Sakatani, K. et al. (2017). Cortical and Cardiovascular Responses to Acute Stressors and Their Relations with Psychological Distress. *International Journal of Psychophysiology, 114*, 38-46. <https://doi.org/10.1016/j.ijpsycho.2017.02.002>
- Cairney, J., & Krause, N. (2005). The Social Distribution of Psychological Distress and Depression in Older Adults. *Journal of Aging and Health, 17*, 807-835.
<https://doi.org/10.1177/0898264305280985>
- Cha, C. B., Najmi, S., Park, J. M., Finn, C. T., & Nock, M. K. (2010). Attentional Bias toward Suicide-Related Stimuli Predicts Suicidal Behavior. *Journal of Abnormal Psychology, 119*, 616-622. <https://doi.org/10.1037/a0019710>
- Cloninger, C. R. (2004). *Feeling Good: The Science of Well-Being*. Oxford University Press. <https://doi.org/10.1093/oso/9780195051377.001.0001>
- Cloninger, C. R., & Zohar, A. H. (2011). Personality and the Perception of Health and Happiness. *Journal of Affective Disorders, 128*, 24-32.
<https://doi.org/10.1016/j.jad.2010.06.012>
- Cloninger, C. R., Zohar, A. H., Hirschmann, S., & Dahan, D. (2012). The Psychological Costs and Benefits of Being Highly Persistent: Personality Profiles Distinguish Mood Disorders from Anxiety Disorders. *Journal of Affective Disorders, 136*, 758-766.
<https://doi.org/10.1016/j.jad.2011.09.046>
- Denollet, J. (2005). DS14: Standard Assessment of Negative Affectivity, Social Inhibition, and Type D Personality. *Psychosomatic Medicine, 67*, 89-97.
<https://doi.org/10.1097/01.psy.0000149256.81953.49>
- Denollet, J., Trompetter, H. R., & Kupper, N. (2021). A Review and Conceptual Model of the Association of Type D Personality with Suicide Risk. *Journal of Psychiatric Research, 138*, 291-300. <https://doi.org/10.1016/j.jpsychires.2021.03.056>
- Elgersma, H. J., Koster, E. H. W., van Tuijl, L. A., Hoekzema, A., Penninx, B. W. J. H., Bockting, C. L. H., & de Jong, P. J. (2018). Attentional Bias for Negative, Positive, and Threat Words in Current and Remitted Depression. *PLOS ONE, 13*, e0205154.
<https://doi.org/10.1371/journal.pone.0205154>
- Föhr, T., Tolvanen, A., Myllymäki, T., Järvelä-Reijonen, E., Rantala, S., Korpela, R., Kujala, U. M. et al. (2015). Subjective Stress, Objective Heart Rate Variability-Based Stress, and Recovery on Workdays among Overweight and Psychologically Distressed Indi-

- viduals: A Cross-Sectional Study. *Journal of Occupational Medicine and Toxicology*, *10*, Article No. 39. <https://doi.org/10.1186/s12995-015-0081-6>
- Glowacz, F., & Schmits, E. (2020). Psychological Distress during the COVID-19 Lockdown: The Young Adults Most at Risk. *Psychiatry Research*, *293*, Article ID: 113486. <https://doi.org/10.1016/j.psychres.2020.113486>
- Jelinek, H. F., & Khandoker, A. H. (2020). Reducing Suicidal Ideation by Biofeedback-Guided Respiration—Heart Rate Coherence. *Digital Psychiatry*, *3*, 1-11. <https://doi.org/10.1080/2575517X.2020.1732733>
- Koelsch, S., Enge, J., & Jentschke, S. (2012). Cardiac Signatures of Personality. *PLOS ONE*, *7*, e31441. <https://doi.org/10.1371/journal.pone.0031441>
- Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: Validity of a Brief Depression Severity Measure. *Journal of General Internal Medicine*, *16*, 606-613. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x>
- Levi-Belz, Y., Gvion, Y., Horesh, N., Fischel, T., Treves, I., Or, E., Apter, A. et al. (2014). Mental Pain, Communication Difficulties, and Medically Serious Suicide Attempts: A Case-Control Study. *Archives of Suicide Research*, *18*, 74-87. <https://doi.org/10.1080/13811118.2013.809041>
- Levi-Belz, Y., Gvion, Y., Levi, U., & Apter, A. (2019). Beyond the Mental Pain: A Case-Control Study on the Contribution of Schizoid Personality Disorder Symptoms to Medically Serious Suicide Attempts. *Comprehensive Psychiatry*, *90*, 102-109. <https://doi.org/10.1016/j.comppsy.2019.02.005>
- Lin, L., Liu, Y., Mo, J., Wang, C., Liu, T., Xu, Z., Wu, X. et al. (2022). Attentional Bias to Emotional Facial Expressions in Undergraduates with Suicidal Ideation: An ERP Study. *Archives of Suicide Research*, *27*, 938-955. <https://doi.org/10.1080/13811118.2022.2096518>
- Linetzky, M., Pergamin-Hight, L., Pine, D. S., & Bar-Haim, Y. (2015). Quantitative Evaluation of the Clinical Efficacy of Attention Bias Modification Treatment for Anxiety Disorders. *Depression and Anxiety*, *32*, 383-391. <https://doi.org/10.1002/da.22344>
- MacLeod, C. M., Mathews, A., & Tata, P. (1986). Attentional Bias in Emotional Disorders. *Journal of Abnormal Psychology*, *95*, 15-20. <https://doi.org/10.1037/0021-843X.95.1.15>
- Manea, L., Gilbody, S., & McMillan, D. (2012). Optimal Cut-Off Score for Diagnosing Depression with the Patient Health Questionnaire (PHQ-9): A Meta-Analysis. *CMAJ: Canadian Medical Association Journal*, *184*, E191-E196. <https://doi.org/10.1503/cmaj.110829>
- McCall, W. V., Rosenquist, P. B., & Miller, B. J. (2022). Development of Autonomic Nervous System Assays as Point-of-Care Tests to Supplement Clinical Judgment in Risk Assessment for Suicidal Behavior: A Review. *Current Psychiatry Reports*, *24*, 11-21.
- Méndez, A. J., Lado, M. J., Vila, X. A., Rodríguez-Liñares, L., Alonso, R. Á., & García-Caballero, A. (2013). Heart of Darkness: Heart Rate Variability in Patients with Risk of Suicide. In *2013 8th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-4). IEEE.
- Miranda, R., Ortin-Peralta, A., Rosario-Williams, B., Kelly, T. F., Macrynika, N., & Sullivan, S. (2021). Understanding Patterns of Adolescent Suicide Ideation: Implications for Risk Assessment. In: R. Miranda, & E. L. Jeglic (Eds.), *Handbook of Youth Suicide Prevention* (pp. 139-158). Springer. https://doi.org/10.1007/978-3-030-82465-5_9
- National Institute of Mental Health. (2012). *Health and Education*.

- <http://www.ncbi.nlm.nih.gov/pubmed/15009358>
- Necho, M., Tsehay, M., Birkie, M., Biset, G., & Tadesse, E. (2021). Prevalence of Anxiety, Depression, and Psychological Distress among the General Population during the COVID-19 Pandemic: A Systematic Review and Meta-Analysis. *International Journal of Social Psychiatry*, *67*, 892-906. <https://doi.org/10.1177/00207640211003121>
- Nunan, D., Sandercock, G. R., & Brodie, D. A. (2010). A Quantitative Systematic Review of Normal Values for Short-Term Heart Rate Variability in Healthy Adults. *Pacing and Clinical Electrophysiology*, *33*, 1407-1417. <https://doi.org/10.1111/j.1540-8159.2010.02841.x>
- Orbach, I., Milstein, I., Har-Even, D., Apter, A., Tiano, S., & Elizur, A. (1991). A Multi-Attitude Suicide Tendency Scale for adolescents. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, *3*, 398-404. <https://doi.org/10.1037/1040-3590.3.3.398>
- Osman, A., Bagge, C. L., Gutierrez, P. M., Konick, L. C., Kopper, B. A., & Barrios, F. X. (2001). The Suicidal Behaviors Questionnaire-Revised (SBQ-R): Validation with Clinical and Nonclinical Samples. *Assessment*, *8*, 443-454. <https://doi.org/10.1177/107319110100800409>
- Osman, A., Barrios, F. X., Grittmann, L. R., & Osman, J. R. (1993). The Multi-Attitude Suicide Tendency Scale: Psychometric Characteristics in an American Sample. *Journal of Clinical Psychology*, *49*, 701-708. [https://doi.org/10.1002/1097-4679\(199309\)49:5<701::AID-JCLP2270490513>3.0.CO;2-X](https://doi.org/10.1002/1097-4679(199309)49:5<701::AID-JCLP2270490513>3.0.CO;2-X)
- Rüesch, A., de Araujo, T. V., Bankwitz, A., Hörmann, C., Adank, A., Ip, C. T., Olbrich, S. et al. (2022). A Recent Suicide Attempt and the Heartbeat: Electrophysiological Findings from a Trans-Diagnostic Cohort of Patients and Healthy Controls. *Journal of Psychiatric Research*, *157*, 257-263. <https://doi.org/10.1016/j.jpsychires.2022.11.020>
- Sahoo, T. K., Mahapatra, A., & Ruban, N. (2019) Stress Index Calculation and Analysis Based on Heart Rate Variability of ECG Signal with Arrhythmia. In *2019 Innovations in Power and Advanced Computing Technologies (i-PACT)* (pp. 1-7). IEEE. <https://doi.org/10.1109/i-PACT44901.2019.8959524>
- Shaffer, F., & Ginsberg, J. P. (2017). An Overview of Heart Rate Variability Metrics and Norms. *Frontiers in Public Health*, *5*, Article 290215. <https://doi.org/10.3389/fpubh.2017.00258>
- Sheridan, D. C., Baker, S., Dehart, R., Lin, A., Hansen, M., Tereshchenko, L. G., Nagel, B. et al. (2021). Heart Rate Variability and Its Ability to Detect Worsening Suicidality in Adolescents: A Pilot Trial of Wearable Technology. *Psychiatry Investigation*, *18*, 928-935. <https://doi.org/10.30773/pi.2021.0057>
- Sumin, A. N., Prokashko, I. Y. & Shcheglova, A. V. (2022). Evaluation of Coping Strategies among Students with Type D Personality. *International Journal of Environmental Research and Public Health*, *19*, Article 4918. <https://doi.org/10.3390/ijerph19084918>
- Thompson, C., & Ong, E. L. C. (2018). The Association between Suicidal Behavior, Attentional Control, and Frontal Asymmetry. *Frontiers in Psychiatry*, *9*, Article 79. <https://doi.org/10.3389/fpsy.2018.00079>
- Utsey, S. O., & Hook, J. N. (2007). Heart Rate Variability as a Physiological Moderator of the Relationship between Race-Related Stress and Psychological Distress in African Americans. *Cultural Diversity and Ethnic Minority Psychology*, *13*, 250-253. <https://doi.org/10.1037/1099-9809.13.3.250>
- Wilson, S. T., Chesin, M., Fertuck, E., Keilp, J., Brodsky, B., Mann, J. J., Stanley, B. et al. (2016). Heart Rate Variability and Suicidal Behavior. *Psychiatry Research*, *240*,

241-247. <https://doi.org/10.1016/j.psychres.2016.04.033>

Wu, C. Y., Lee, M. B., Liao, S. C., Chan, C. T., Liu, L. Y. D., & Chen, C. Y. (2020). Psychological Distress of Suicide Attempters Predicts One-Year Suicidal Deaths during 2007-2016: A Population-Based Study. *Journal of the Formosan Medical Association, 119*, 1306-1313. <https://doi.org/10.1016/j.jfma.2020.04.033>

Zohar, A. H. (2016). Is Type-D Personality Trait(s) or State? An Examination of Type-D Temporal Stability in Older Adults in the Community. *PeerJ, 3*, e1499v1. <https://doi.org/10.7287/peerj.preprints.1499v1>

Zohar, A. H., & Cloninger, C. R. (2011). The Psychometric Properties of the TCI-140 in Hebrew. *European Journal of Psychological Assessment, 27*, 73-80. <https://doi.org/10.1027/1015-5759/a000046>

Zohar, A. H., Cloninger, C. R., & McCraty, R. (2013). Personality and Heart Rate Variability: Exploring Pathways from Personality to Cardiac Coherence and Health. *Open Journal of Social Sciences, 6*, 32-39. <https://doi.org/10.4236/jss.2013.16007>

Zohar, A. H., Denollet, J. K., Lev Ari, L., & Cloninger, C. R. (2011). The Psychometric Properties of the DS14 in Hebrew and the Prevalence of Type D in Israeli Adults. *European Journal of Psychological Assessment, 27*, 274-281. <https://doi.org/10.1027/1015-5759/a000074>