Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Research paper

Learning it the hard way – how enjoying life and positive appraisal buffer the negative effects of stressors on mental health in the COVID-19 pandemic

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ABSTRACT

Background: Higher levels of stress and negative emotions such as anxiety and depression have been reported since the beginning of the COVID-19 pandemic, but it remains less clear how positive emotions, such as hedonic capacity, may be affected. Further, during lockdowns, the ability to learn new pleasurable activities (hedonic learning) may be particularly relevant. Here, we investigated if state hedonia and/or hedonic learning mediated the relationship between COVID-19 stress and mental health. Moreover, we explored whether positive appraisal style (PAS), a major resilience factor, influenced these relationships.

Methods: Using a cross-sectional design, 5000 German-speaking participants filled out online questionnaires targeting stressors, mental health, state hedonia, hedonic learning, and PAS between April 9 and May 15, 2020. After confirming the factor structure of our constructs, we applied latent structural equation modeling to test mediation as well as moderated mediation models.

Results: Stress showed a positive association with mental health symptoms, which was buffered by both state hedonia and hedonic learning. While higher stress was related to lower state hedonia, participants reported more hedonic learning with greater stressor load. The latter effect was greater for individuals with high PAS.

Limitations: The present results should be replicated in longitudinal designs with representative samples to confirm the directionality and generalizability of effects.

Conclusions: Both state hedonia and hedonic learning buffered the effect of stress on mental health in an early phase of the COVID-19 pandemic. Learning new rewarding activities in combination with a PAS may be especially relevant for maintaining mental health during lockdowns.

1. Introduction

Globally, the psychological impact of the ongoing coronavirus disease 2019 (COVID-19) pandemic is closely investigated. Recent studies reported a deterioration of mental health and well-being (Möhring et al., 2021; Pan et al., 2021; Paredes et al., 2021; Patrick et al., 2020; Pierce et al., 2020; Zacher and Rudolph, 2021), high levels of stress (Cooke et al., 2020), as well as increasing anxiety and depression symptoms (Bueno-Notivol et al., 2021; Cénat et al., 2021; Fiorillo et al., 2020; Henssler et al., 2020; McCracken et al., 2020; Pappa et al., 2020; Petzold et al., 2020; Pieh et al., 2020; Prati and Mancini, 2021; Probst et al., 2020). However, less evidence is available for the COVID-19 impact on positive psychological functioning (Prati and Mancini, 2021) or potential mediating effects of positivity with regard to mental health (Veer

Abbreviations: aBIC, sample-size adjusted BIC; ACIPS, Anticipatory and Consummatory Interpersonal Pleasure Scale; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; CFA, confirmatory factor analysis; CFI, comparative fit index; CI, confidence interval; COVID-19, coronavirus disease 2019; DARS, Dimensional Anhedonia Rating Scale; EFA, exploratory factor analysis; GHQ-12, 12-item General Health Questionnaire; MLR, robust maximum likelihood; PAS, positive appraisal style; RMSEA, root mean square error of approximation; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SEM, structural equation modeling; SRMR, standardized root mean square residual; TEPS, Temporal Experience of Pleasure Scale; TLI, Tucker Lewis index.

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et al., 2021). Positive affect is a major part of subjective well-being and mental health (Keyes, 2005; Kringelbach and Berridge, 2017) and daily positive experiences can contribute to health (Sin and Almeida, 2018). For instance, positive appraisal style (PAS), defined as the general tendency to evaluate potentially aversive situations non-negatively (Kalisch et al., 2015), was positively related to resilience during the COVID-19 pandemic in a recent study by our group (Veer et al., 2021). Here, we focused on hedonic capacity, the ability to experience pleasure and enjoy recreational activities, as a protective factor for maintaining mental health despite stressors in the COVID-19 pandemic.

The COVID-19 pandemic may have affected the experience of positive emotions due to ensuing restrictions on leisure and social activities. In March 2020, infection rates grew exponentially in several European countries, causing many of them to impose their first "lockdown". Lockdown implies mitigation strategies to slow the spread of the novel coronavirus (SARS-CoV-2), including strict contact restrictions and physical distancing, and the closing of schools and large parts of non-essential infrastructure. Daily routines were fundamentally changed, individuals were asked to work in home offices, and day care centers for children were closed. Opportunities for leisure activities were severely restricted as, for instance, bars and restaurants, theaters, playgrounds, sports clubs, and concerts were closed or cancelled, and social gatherings were limited. Several studies corroborate the impact of COVID-19 related restrictions on positive recreational activities (Ammar et al., 2020; Klaiber et al., 2021; Lehmiller et al., 2020; Moore et al., 2020; Mutz and Gerke, 2020). In Germany, a representative online study (Mutz and Gerke, 2020) reported a significant decline in leisure time sport and exercise at population level during the first weeks of the lockdown. In the US, changes in recreational sexual behavior were examined: 43.5% reported a decrease and only 13.6% an improvement of the quality of their sex lives (Lehmiller et al., 2020).

If individuals experience fewer positive emotions due to COVID-19 stressors and related restrictions on leisure activities, it is currently not sufficiently established whether their capacity to experience pleasure will be altered or not and, if so, how their mental health will be affected. The loss of pleasure or interest in activities usually enjoyed is clinically known as anhedonia, which is a severe symptom of many psychiatric disorders, such as depression (Rizvi et al., 2016; Treadway and Zald, 2011) and schizophrenia (Gard et al., 2007; Lambert et al., 2018; Ritsner et al., 2018). Further, anhedonia has repeatedly been associated with a higher risk of developing a mental disorder (Gooding et al., 2005; Kwapil, 1998; Luby et al., 2018; Stringaris et al., 2015; Ward et al., 2019). Research on the interaction of stress, anhedonia, and mental health suggests a mediating role of anhedonia. In this model, anhedonia originates from dysfunctional interactions of brain reward systems and stress (Corral-Frías et al., 2015; Pizzagalli, 2014; Stanton et al., 2019). In turn, stress-related anhedonia is associated with psychopathology, such as depression or alcohol abuse (Corral-Frías et al., 2015; Pizzagalli, 2014). First evidence for the role of hedonic capacity for mental health in the pandemic comes from a cross-sectional study during the early Italian lockdown, where reduced hedonic tone significantly predicted depression severity (Moccia et al., 2021).

As stated above, state hedonia can be roughly described as the current capacity to experience pleasure. Yet it cannot be reduced to consummatory pleasure, i.e., the pleasure experienced at the receipt of a reward. Research on reward processing has differentiated several subcomponents, with partly distinct neural mechanisms, which all interact in a healthy hedonic response (Berridge and Robinson, 2003; Kringelbach et al., 2012). Besides consummatory pleasure, anticipatory pleasure, motivation, effort-based decision making, and reward learning are often discussed (Der-Avakian and Markou, 2012; Husain and Roiser, 2018; Rømer Thomsen et al., 2015; Treadway and Zald, 2013). Importantly, an impairment in any of these subcomponents could potentially lead to a strong reduction of pleasure in one's life. Therefore, recently developed (an)hedonia scales, such as the Dimensional Anhedonia Rating Scale (DARS) (Rizvi et al., 2015), the Temporal Experience of Pleasure Scale (TEPS) (Gard et al., 2006), or the Anticipatory and Consummatory Interpersonal Pleasure Scale (ACIPS) (Gooding and Pflum, 2014) assess more than consummatory pleasure. While the TEPS and ACIPS focus on anticipatory and consummatory components of pleasure, the DARS was designed to capture interest/desire, motivation, effort, and consummatory pleasure. However, despite in-depth research on the behavioral (Huys et al., 2013) and neural (Garrison et al., 2013) level, the process of reward learning is not assessed in self-report (an) hedonia scales.

The aim of this study was to assess state hedonic capacity and mental health during the early stages of the COVID-19 pandemic. Considering the exceptional and dynamic circumstances of the pandemic and the pressure to adapt one's daily routines, we believe the capacity and motivation to learn new enjoyable activities may be of incremental importance. Thus, we introduced a self-formulated measure of state reward learning, termed hedonic learning, in our study. We hypothesized that both state hedonia and hedonic learning would mediate the association of stress and mental health in separate models. Given the recent finding on the stress-buffering role of PAS in the COVID-19 pandemic (Veer et al., 2021), we examined, as a further exploratory analysis, whether the presumed indirect effect from stress to mental health via state hedonia/hedonic learning was moderated by PAS.

2. Methods

2.1. Design and procedure

The present study had a cross-sectional, observational design, using the first wave of data from a longitudinal online survey ("COV-ELAN: Enjoying Life – The (AN)hedonic Spectrum During the COVID-19 Pandemic") on the Unipark platform (www.unipark.com). For the first wave, we collected data mainly in Germany (93.9%), as well as in Austria and Switzerland between April 9, 2020 (when in Germany 108,202 cases of infection and 2107 deaths attributed to COVID-19 were reported) and May 15, 2020 (173,152 infections and 7824 deaths) (Robert Koch Institut, 2021). We utilized a snowball sampling strategy to achieve a maximally large study sample given the resources available to us. The link to the survey was distributed widely on various mailing lists, websites, and social media platforms. Participants gave informed consent electronically and were offered the opportunity to partake in a raffle of ten €100 vouchers and to receive an individual feedback on their responses if they completed all study waves. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. The study procedure was approved by the local ethics committee of the Charité – Universitätsmedizin Berlin (reference no. EA2/065/19).

2.2. Participants

Participants were eligible if they were at least 18 years old and exhibited sufficient German proficiency. Initially, 6846 participants accessed the online survey. Of these, after quality checks ($n = 9$ participated a second time, $n = 4$ did not meet the cut-off for minimum duration of completing the survey, $n = 10$ did not display sufficient response variance), there remained $n = 1823$ participants who were excluded from further analysis because they did not complete the stressor exposure items at the end of the survey which were required to test the hypotheses. In the remaining sample ($n = 5000$), the mean age was 40.4 (SD = 14.6), with 58.2% female participants. For further sociodemographic characteristics, see Table 1 and online supplementary Table S1.

2.3. Measures

Our online study comprised a battery of several psychological scales

Table 1
Main sociodemographic characteristics and descriptive statistics of main variables.

	Full sample(n = 5000)	EFA subsample(n = 1000)	CFA/SEM subsample (n = 4000)
Age (years)[a]			
Mean (SD)	40.4 (14.6)	40.8 (14.9)	40.2 (14.6)
Median [Min, Max]	39.0 [18.0, 84.0]	39.5 [18.0, 84.0]	39.0 [18.0, 83.0]
Gender: n (%)			
Female	2911 (58.2)	582 (58.2)	2329 (58.2)
Male	2061 (41.2)	414 (41.4)	1647 (41.2)
Diverse	28 (0.6)	4 (0.4)	24 (0.6)
Highest degree of education: n (%)			
No degree	7 (0.1)	1 (0.1)	6 (0.2)
In school	33 (0.7)	7 (0.7)	26 (0.7)
Secondary	411 (8.2)	86 (8.6)	325 (8.1)
Advanced	2002 (40.0)	389 (38.9)	1613 (40.3)
University	2544 (50.9)	517 (51.7)	2027 (50.7)
Other	3 (0.1)	0 (0.0)	3 (0.1)
Stress			
Mean (SD)	8.9 (3.3)	8.8 (3.3)	8.9 (3.3)
Median [Min, Max]	8.6 [0.0, 23.0]	8.8 [0.0, 20.8]	8.6 [0.0, 23.0]
Cronbach's α	.84	.83	.84
Mental health (GHQ-12)			
Mean (SD)	14.3 (6.8)	14.3 (6.7)	14.3 (6.9)
Median [Min, Max]	13.0 [0.0, 36.0]	13.0 [0.0, 36.0]	13.0 [0.0, 36.0]
Cronbach's α	.88	.88	.88
PAS			
Mean (SD)	10.8 (2.7)	10.8 (2.7)	10.8 (2.8)
Median [Min, Max]	11.0 [3.0, 15.0]	11.0 [3.0, 15.0]	11.0 [3.0, 15.0]
Cronbach's α	.68	.65	.68
State hedonia (DARS)[b]			
Mean (SD)	69.8 (11.0)	70.1 (10.6)	69.8 (11.1)
Median [Min, Max]	71.0 [0.0, 88.0]	71.0 [18.0, 88.0]	71.0 [0.0, 88.0]
Cronbach's α	.89	.89	.89
Hedonic learning			
Mean (SD)	19.6 (12.1)	19.7 (12.2)	19.6 (12.1)
Median [Min, Max]	18.5 [0.0, 60.0]	18.0 [0.0, 60.0]	19.0 [0.0, 59.0]
Cronbach's α	.91	.91	.90

Note. Cronbach's α reported as measure of internal consistency. EFA = exploratory factor analysis; CFA = confirmatory factor analysis; SEM = structural equation modeling; GHQ-12 = 12-item General Health Questionnaire; PAS = Positive appraisal style items; DARS = Dimensional Anhedonia Rating Scale. For further sociodemographic information, see online supplementary Table S1.

[a] n = 3 missing.

[b] n = 118 missing as no examples were given for one or more hedonic domains.

as well as detailed sociodemographic questions. Completion of all questions took on average 36.1 min (SD = 28.3). Here, we only report measures included in the present analysis.

2.3.1. Stress

Twenty-three self-formulated items measured potential stressors during the last two weeks. Sixteen items specifically targeted COVID-19 related stressors, seven items asked about more general sources of stress (see online supplementary Table S3). Participants reported whether the stressor had occurred (coded as zero if not applicable). If applicable, they were further asked to report how burdensome it was to them on a five-point Likert scale from 1 (not at all burdensome) to 5 (extremely burdensome). Since the general stressors might well be influenced by the COVID-19 pandemic, even if they did not specifically reference it, we computed a total stress score in the range of 0 to 23 as a weighted sum of all 23 items.

2.3.2. Mental health

The widely used General Health Questionnaire in its 12-item version (GHQ-12) with a four-point (0–3) Likert scale was used to screen for mental health symptoms (Goldberg et al., 1997; Schrnitz et al., 1999). With this scoring scheme, the total score ranges from 0 to 36, higher values reflecting more severe mental distress.

2.3.3. Positive appraisal style

For the sake of brevity, PAS was assessed by only three items of the Cognitive Emotion Regulation Questionnaire 18-items short version (CERQ-short) (Garnefski and Kraaij, 2006; Loch et al., 2011), adapted in wording in order to assess emotion regulation during negative or unpleasant events in the past two weeks: "I thought that the situation also has its positive sides", "I thought that it hasn't been too bad compared to other things", "I thought that I have to accept the situation". Items were rated on a five-point Likert scale from 1 (fully disagree) to 5 (fully agree), with sum scores ranging from 3 to 15. Conceptually, these items belong to the positive reappraisal, putting into perspective, and acceptance subscales of the CERQ-short. This is compatible with the definition of PAS as a broader concept (Kalisch et al., 2015; Veer et al., 2021).

2.3.4. Trait hedonia

TEPS (Gard et al., 2006; Simon et al., 2018) and ACIPS (Gooding and Pflum, 2014; German translation by D.C. Gooding & K. Kirst, 2015, personal communication), two trait measures of physical and social (an) hedonia, were included to evaluate the validity of the hedonic learning scale (see below). Higher scores indicate more hedonia.

2.3.5. State hedonia

The DARS (Blackwell et al., 2018; Rizvi et al., 2015) measures state (an)hedonia across the four hedonic domains hobbies (4 items), food/-drink (4 items), social activities (4 items), and sensory experiences (5 items) and integrates interest/desire, motivation, effort, and consummatory pleasure. The 17 items are rated on a five-point Likert scale from 0 (not at all) to 4 (very much), higher values indicating more hedonic capacity. In contrast to other (an)hedonia scales, participants are asked to name two or three of their own favorite pleasurable activities for each domain. Then, they rate the items referring to their own preferences. We counted ratings as valid only if examples for the respective domain were provided. Principal component analysis revealed four components mapping onto the hedonic domains (Rizvi et al., 2015). Given the importance of sexuality and other forms of physical intimacy as sources of pleasure (Georgiadis and Kringelbach, 2012) and the potential effects of distancing measures on people's intimate lives (Lehmiller et al., 2020), we decided to add *physical intimacy* as a fifth hedonic domain and repeated the five items of the sensory experience subscale with regard to this domain. The total sum score in this extended DARS thus ranges from 0 to 88.

2.3.6. COVID-19 restrictions on pleasant activities

Physical distancing measures likely impact the availability of the usual sources of hedonic experiences. We asked our participants to what extent during the last two weeks the COVID-19 pandemic restricted them in pursuing the activities they most preferred before the pandemic had started. The participants answered separately for each of the five hedonic domains on a five-point Likert scale from 0 (not at all) to 4 (very much).

2.3.7. Hedonic learning

To assess hedonic learning, we generated items in strong similarity to the extended DARS by distinguishing the same five hedonic domains (hobbies, food/drink, social activities, sensory experiences, and physical intimacy) and using the same five-point Likert scale. Here, however, we specifically focused on new hedonic experiences and activities. For each domain, three items were provided, e.g., for the sensory domain: "I spend effort to learn new sensory experiences I can enjoy", "I discover new sensory experiences I enjoy", "I would like to learn new sensory experiences that I might enjoy". Participants rated how well these

statements applied to them during the last two weeks, with total sum scores ranging from 0 to 60. Moreover, instead of asking for examples of the participants' own favorite activities or experiences, for each domain they were asked to indicate the percentage of their current favorite activities that were new compared to the three months before the COVID-19 pandemic. These ratings as well as the DARS, TEPS, and ACIPS scores were used to assess validity. We proposed that hedonic learning should be moderately correlated to state and trait measures of hedonia but also to the actual amount of new enjoyable activities.

2.4. Analysis

Data cleaning and analysis were performed using Python 3.7 and R 4.0.3 (R Core Team, 2020). For all analyses, a two-tailed significance level of $\alpha = 0.05$ was applied, unless otherwise specified.

In order to evaluate our hypotheses considering the indirect effect of stress on mental health via state hedonia/hedonic learning, we applied latent structural equation modeling (SEM) using the R package lavaan, version 0.6–7 (Rosseel, 2012). In SEM, the relations among latent constructs and their manifest indicators (the measurement model), and the relations among constructs (the structural model) are estimated separately, thereby controlling for measurement error (Kline, 2016). Before setting up the structural model, the factor structure of the constructs, i.e., the measurement model, should be evaluated (Anderson and Gerbing, 1988; Kline, 2016). To test the factor structure of the extended DARS and the self-generated hedonic learning scale, we randomly split our sample and performed 1) exploratory factor analyses (EFA; $n = 1000$) and 2) confirmatory factor analyses (CFA; $n = 4000$) of the respective measurement models to 1) establish and 2) cross-validate the constructs (see online supplementary material). In addition, the factor structure of the GHQ-12 was confirmed prior to testing the structural models (see online supplementary material). As described above, the stress score was computed as the weighted sum of COVID-19 and general stressors and was treated as a manifest variable in SEM.

Next, we defined mediation models (see Figs. 1 and 2) in the confirmatory subsample ($n = 4000$). The following covariates, previously identified as risk factors for developing mental health problems during the COVID-19 pandemic, were included: age, gender, socioeconomic status (education, employment status), as well as a history of physical or mental health problems (Luo et al., 2020; Xiong et al., 2020). To assess the significance of the indirect effects, 95% nonparametric percentile bootstrap confidence intervals (CI) were computed based on 5000 samples (Cheung, 2007; Falk, 2018). As we were further interested in exploring the moderating influence of PAS on the indirect effect of stress on mental health via state hedonia/hedonic learning, we compared the mediation models between participants with high and low PAS. Significant differences in path coefficients indicate moderation (Sass and Schmitt, 2013). For further details, please see the online supplementary material.

Robust maximum likelihood (MLR) estimation method was used for CFA and SEM analyses, as this method does not presume multivariate normality and yields robust measures of fit and standard errors (Kaplan, 2009). Although MLR is not developed for ordinal data, it has been found to perform well, especially in large samples and with five or more categories (Bandalos, 2014; Byrne, 2012; Li, 2016). Missing data was handled by specifying full information maximum likelihood which uses all of the available information to obtain model parameters while accounting for missing data (Gallagher and Brown, 2013). Seven fit indices, the comparative fit index (CFI), the Tucker Lewis index (TLI), the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and the sample-size adjusted BIC (aBIC) were considered in their robust variants to determine model fit. Lower AIC and BIC values indicate a better fit when comparing different models. We followed Hu and Bentler (1999) in interpreting values higher than .95 for CFI and TLI, and values smaller than .06 for RMSEA and .08 for SRMR as indication of good fit. In light of controversies regarding the exact cutoff criteria and the overgeneralization of Hu and Bentler's findings (Hu and Bentler, 1999; Marsh et al., 2004), we interpreted CFI and TLI over .90 and RMSEA

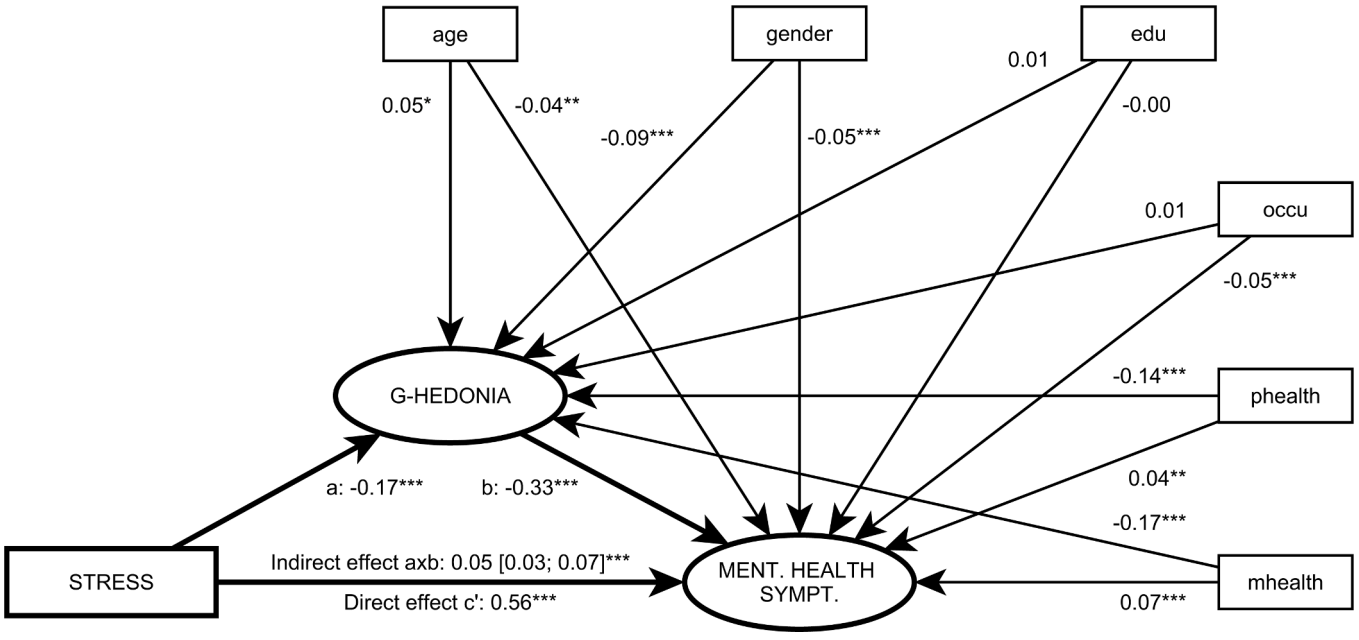

Fig. 1. Structural equation model with state hedonia as mediator of the relation between COVID-19 stress and mental health symptoms, controlling for relevant covariates. Latent variables are depicted as circles, manifest variables as squares. Standardized coefficients reported. For the indirect effect axb, corresponding 95% nonparametric percentile bootstrap confidence interval displayed in square brackets. Dummy-coded: gender (reference = female; only male shown). For unstandardized coefficients, see online supplementary Table S11. Manifest indicators of latent variables, latent domain group factors, and (co-)variances not depicted. G-HEDONIA = general factor state hedonia; MENT. HEALTH SYMPT. = mental health symptoms; edu = highest degree of education obtained; occu = employment status (dichotomized: 1 = employed; 0 = not employed); phealth = general physical health (1 = excellent; 5 = poor); mhealth = mental health prior to the COVID-19 pandemic (1 = excellent; 5 = poor). *$p < .05$; **$p < .01$; ***$p < .001$.

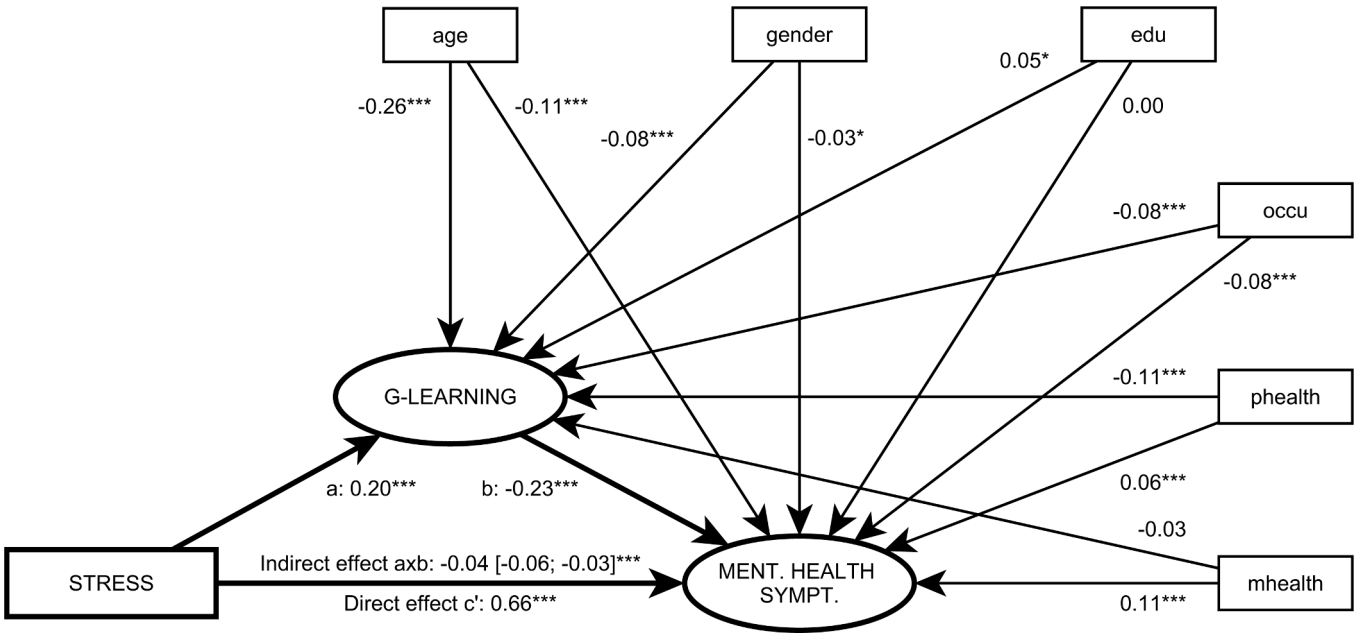

Fig. 2. Structural equation model with hedonic learning as mediator of the relation between COVID-19 stress and mental health symptoms, controlling for relevant covariates. Latent variables are depicted as circles, manifest variables as squares. Standardized coefficients reported. For the indirect effect axb, corresponding 95% nonparametric percentile bootstrap confidence interval displayed in square brackets. Dummy-coded: gender (reference = female; only male shown). For unstandardized coefficients, see online supplementary Table S12. Manifest indicators of latent variables, latent domain group factors, and (co-)variances not depicted. G-LEARNING = general factor hedonic learning; MENT. HEALTH SYMPT. = mental health symptoms; edu = highest degree of education obtained; occu = employment status (dichotomized: 1 = employed; 0 = not employed); phealth = general physical health (1 = excellent; 5 = poor); mhealth = mental health prior to the COVID-19 pandemic (1 = excellent; 5 = poor). *$p < .05$; ***$p < .001$.

under .10 as still acceptable (Hopwood and Donnellan, 2010). The χ^2-test of absolute fit is reported, but note that in large sample sizes even trivial misspecifications will lead to a significant result and, thus, rejection of the model (Bentler and Bonett, 1980).

3. Results

3.1. Descriptive results for complete sample

Table 1 shows the descriptive statistics and internal consistency for the main variables in the present study. The total stress score was minimally positively skewed, so that slightly more participants provided lower stress severity ratings. The most frequently reported stressor was "Corona-related media coverage" (98.4%), followed by "Feelings of anxiety, worry or other negative emotions because of the effects of the Corona-crisis on society" (96.6%), and "Not being able to perform leisure activities" (95.9%). The stressor experienced as most severe on a scale from 0 to 5 was "Not being able to perform leisure activities" (3.4), followed by "Loss of social contact" (3.2), and "Feelings of anxiety, worry, or other negative emotions because of the effects of the Corona-crisis on society" (3.2). For all stressor counts and ratings, see online supplementary Table S3. The GHQ-12 total score was moderately positively skewed, indicating slightly more participants with less internalizing symptoms (Table 1; however, the scores were higher than previously observed in a representative German sample prior to the pandemic, $M = 9.7$, SD = 4.9 (Romppel et al., 2017)). Further, participants who self-reported a past or present mental health diagnosis showed higher scores ($M = 16.3$, SD = 7.6) than those without ($M = 13.4$, SD = 6.3; $t(4998) = 13.96$, $p < .0001$). PAS total score was moderately negatively skewed, indicating more higher values in our sample. The extended DARS score was highly negatively skewed, with more participants displaying higher state hedonia across all five pleasure domains. Considering hedonic domains, the most restrictions were perceived for social activities (online supplementary Table S4). The hedonic learning score was minimally positively skewed, i.e., participants tended to report less hedonic learning across all five pleasure domains. The greatest percentage of new activities was reported within the domain of hobbies (see online supplementary Table S4). Considering convergent validity, hedonic learning showed small to moderate correlations with state hedonia as measured by the DARS (Spearman's $r_s = 0.29$, $p < .0001$) as well as with trait social hedonia as measured by the ACIPS ($r_s = 0.36$, $p < .0001$) and trait physical hedonia as measured by the TEPS ($r_s = 0.32$, $p < .0001$). In comparison, the DARS showed similarly moderate correlations ($r_s = 0.44$, $p < .0001$; $r_s = 0.42$, $p < .0001$; for trait social and physical hedonia, respectively). Within each domain, there was a moderate to strong correlation between learning and the percentage of new activities among the current favorite activities (see online supplementary Table S4).

3.2. Measurement models in confirmatory subsample

The results of EFA and CFA are reported in the online supplementary material. The fit indices of the measurement models for DARS, hedonic learning, and GHQ-12 are depicted in Table 2. For the DARS, the five factors resembling the five domains emerged, thereby confirming that the newly added domain of physical intimacy can be clearly distinguished from the four already established domains (Arrua-Duarte et al., 2019; Rizvi et al., 2015). We specified an orthogonal bifactor model with one general state hedonia factor and five domain group factors. For hedonic learning, we determined a bifactor model with general hedonic learning, five domain group factors, and correlated error terms between every third item. The GHQ-12 was modeled as unidimensional with correlated errors for negatively worded items and transformed into six parcels (Little et al., 2013). Good fit for all models was established. For reasons of parsimony, we chose to integrate only the general factors of DARS (general state hedonia factor) and hedonic learning (general hedonic learning factor) into the mediation models.

Table 2
Fit indices of the measurement and structural models.

	χ^2	df	CFI	TLI	RMSEA [90% CI]	SRMR	AIC	BIC	aBIC
Measurement models									
State hedonia (DARS)[a]	2640.409	187	.933	.917	.064 [.062; 0.067]	.054	183,994.176	184,408.064	184,198.346
Hedonic learning	773.684	65	.979	.966	.059 [.055; 0.062]	.028	153,045.880	153,392.053	153,217.287
Mental health (GHQ-12)	139.138	6	.986	.965	.081 [.069; 0.093]	.022	41,299.748	41,394.159	41,346.495
Structural models									
State hedonia[a] as mediator	5629.931	532	.909	.897	.052 [.051; 0.053]	.063	316,073.698	317,143.687	316,603.502
Hedonic learning as mediator	2822.480	312	.952	.942	.047 [.045; 0.049]	.039	281,402.146	282,358.842	281,875.854

Note. $n = 4000$. Robust fit indices reported. DARS measurement model: bifactor with five domain group factors. Hedonic learning measurement model: bifactor with five domain group factors and correlated error terms of every third item. GHQ-12 measurement model: one factor with correlated errors of negatively worded items in six parcels. CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; aBIC = sample-size adjusted Bayesian Information Criterion.
[a] $n = 91$ missing as no examples were given for one or more hedonic domains.

3.3. Structural models in confirmatory subsample

3.3.1. State hedonia as mediator of the relation between stress and mental health

The mediation model (Fig. 1) provided acceptable fit to the data (Table 2). Standardized regression coefficients are reported in Fig. 1, for unstandardized coefficients, see online supplementary Table S11. Stress was positively associated with mental health symptoms and negatively associated with state hedonia, which in turn negatively predicted mental health symptoms, controlling for relevant covariates. For mental health symptoms, 57.7% of variance was explained; for state hedonia, 12.3%. There was a significant indirect effect of stress on mental health symptoms via state hedonia, as the corresponding 95% nonparametric percentile bootstrap CI did not contain zero (Fig. 1).

3.3.2. Hedonic learning as mediator of the relation between stress and mental health

The mediation model (Fig. 2) displayed appropriate fit to the data (Table 2). Standardized regression coefficients are reported in Fig. 2, for unstandardized coefficients, see online supplementary Table S12. Stress positively predicted mental health symptoms as well as hedonic learning, which in turn negatively predicted mental health symptoms, controlling for relevant covariates. For mental health symptoms, 52.1% of variance was explained; for hedonic learning, 16.3%. There was a significant indirect effect of stress on mental health symptoms via hedonic learning, as the corresponding 95% nonparametric percentile bootstrap CI did not cross zero (Fig. 2).

3.4. Exploratory analyses: moderated mediation in confirmatory subsample

3.4.1. Moderation of the mediating effect of state hedonia by PAS

The indirect effect of stress on mental health via state hedonia was not significantly moderated by PAS (see online supplementary material).

3.4.2. Moderation of the mediating effect of hedonic learning by PAS

The relationship between stress and hedonic learning differed significantly dependent on PAS level (see online supplementary material). Specifically, individuals with high PAS learned more given higher stressor impact. This effect pattern corresponds to first-stage moderated mediation (Sardeshmukh and Vandenberg, 2016), i.e., the first stage of the indirect effect of stress on mental health symptoms via hedonic learning was moderated.

4. Discussion

In an early phase of the COVID-19 pandemic, we found evidence for a mediating role of state hedonia as well as hedonic learning in the relation between stress and mental health symptoms. Although both state hedonia and hedonic learning buffered the detrimental effect of stress on mental health, there may be different underlying mechanisms. Whereas higher stressor load was negatively related to state hedonia, it was positively associated with hedonic learning. Moreover, we observed that PAS only moderated the stress-buffering effect of hedonic learning, but not of state hedonia. In other words, individuals who reported higher PAS may have been more likely to counteract stress with learning new hedonic activities. Importantly, our findings were robust when controlling for sociodemographic variables that have previously been shown to be relevant for mental health during the COVID-19 pandemic.

Our results support a potentially protective role of hedonic capacity against COVID-19 stressor-induced mental distress. It is well known that stress can lead to anhedonia which in turn may increase the risk for developing mental disorders (Corral-Frías et al., 2015; Pizzagalli, 2014; Stanton et al., 2019), is related to worse treatment outcome in depression (McMakin et al., 2012; Uher et al., 2012), and poor functional outcome in schizophrenia (Kiwanuka et al., 2014). Lack of control over stressors, in particular, further exacerbates these relations (Pizzagalli, 2014). The COVID-19 pandemic, especially in its early phase, was a particularly uncontrollable and enduring situation. Our findings are consistent with a recent study where reduced hedonic tone predicted COVID-19 related depression severity in an early phase of the pandemic in Italy (Moccia et al., 2021). Further, pursuing hobbies or spending time outdoors during the pandemic predicted more positive, and less negative affect (Lades et al., 2020; Stieger et al., 2021) as well as lower levels of depressive symptoms (Fullana et al., 2020). Thus, engaging in positive activities may be an important strategy to enhance well-being and mitigate the risk of developing mental disorders during the current crisis (Klaiber et al., 2021). This effect may function via positive distraction. Especially in the initial phase of disasters, positive distraction from stressors can enhance the experience of positive emotions (Shing et al., 2016). In turn, a positive attitude in this phase can protect individuals from becoming overwhelmed and help them build resources that enable future coping (Waugh, 2013).

Of note, our results provide novel evidence that learning to engage in new rewarding activities, i.e., hedonic learning, may have a buffering effect on the stressor-mental distress relation in the COVID-19 pandemic. How well individuals fare during and after disasters may partly depend on their ability to match their coping strategies to the unique psychological and physical demands at hand (Cheng et al., 2014; Shing et al., 2016). Increased difficulties to stabilize mood via pleasant

activities during the first lockdown were associated with a reduction in the range of activities in a cohort study of Dutch students (Taquet et al., 2021). Further, the restrictions on leisure and social activities were one of the most frequent and severely rated stressors in our sample. When lockdown measures are in place and habitual responses are blocked, the willingness to actively search and try out new activities to maintain positive mood may be especially relevant. Corroborating our results of heightened hedonic learning given greater stress, feeling stressed and lonely was associated with trying out new sexual activities during the pandemic (Lehmiller et al., 2020). Moreover, participants who added new activities were more likely to report a greater improvement in their sex life. Additionally, the present exploratory analyses show that the effect of hedonic learning is enhanced in individuals with a high PAS, a major factor contributing to resilience (Kalisch et al., 2015; Veer et al., 2021).

In our sample, mental health problems were increased compared to representative values measured with the same instrument (GHQ-12) prior to the COVID-19 pandemic (Romppel et al., 2017). A similar increase in GHQ-12 scores in April 2020, compared with in 2018–19, has been reported among adults in the UK (Pierce et al., 2020). For our construct of interest, hedonic capacity, we observed levels comparable to pre-COVID-19 studies, e.g., Rizvi et al. (2015). Our findings are in line with a recent meta-analysis of longitudinal studies where COVID-19 lockdowns increased mental health symptoms, but did not significantly affect positive psychological functioning (Prati and Mancini, 2021). Our results encourage the view that people may be able to actively counteract the negative impact of COVID-19 stressors and lockdown measures via elements of positive psychology, i.e., state hedonia, hedonic learning, and PAS.

4.1. Strengths and limitations

Among the strengths of our study are the relatively large sample size, allowing for a split into subsamples for exploratory and confirmatory factor analyses, as well as the use of latent SEM to test the mediation effects controlling for measurement error. Moreover, we measured a variety of individual stressors and exclusively relied on recent questionnaires that assess trait and state hedonia in line with the current conceptualization as a multi-faceted phenomenon. We further included new items targeting hedonic learning to capture the unique and dynamic challenges posed towards hedonic experiences during lockdowns. First indications for validity were given, as the total score of these items was significantly associated with established hedonia measures (convergent validity) and the percentage of new activities that participants reported (criterion validity).

However, several limitations must be acknowledged. First, this was the initial attempt to validate our construct of hedonic learning due to the need to quickly assess the initial impact of the pandemic. Consequently, we may have failed to capture all facets relevant to the construct. Moreover, we cannot exclude that the effects of hedonic learning may be partly attributable to higher-order abilities that we did not assess, e.g., psychological flexibility (Dawson and Golijani-Moghaddam, 2020; Pakenham et al., 2020). Future research is therefore needed, specifically to learn about boundaries regarding neighboring constructs (discriminant validity). This may help to disentangle overlapping and distinctive influences of this construct. Second, the cross-sectional design does not allow for causal inferences regarding the directionality of the mediation effects. Even though it is consistent with theory and empirical observations that impaired hedonic capacity is a precursor to mental disorders, the causal effects could be in the reverse direction or bidirectional. Third, the current results reflect the initial emotional reaction to the pandemic which may stabilize or change dependent on further developments. Longitudinal studies can provide further insight into the directionality of effects, their stability over time, and what other factors beyond hedonic capacity may be relevant as the situation proceeds. The present findings will be extended by longitudinal analyses that we will conduct in a next step. Fourth, we used convenience sampling, yielding a non-random sample. Thus, our results cannot be generalized to the population. Finally, we were only able to include online self-report measures due to the restrictions on face-to-face contact, which, aside from the well-known limitations of self-reports (e.g., Paulhus and Vazire, 2007), disables the participation of individuals without internet access or familiarity with online surveys.

4.2. Conclusions

In conclusion, our findings confirm an increase in mental burden in the general population during the COVID-19 pandemic which, however, may be mitigated via factors related to hedonia and positive appraisal. We showed that hedonic capacity may have been a protective factor in the initial phase of the pandemic. Actively searching and trying out new pleasant activities (hedonic learning) may be especially relevant for individuals under high stress. This effect is enhanced by a major resilience factor, PAS (Kalisch et al., 2015). Importantly, both hedonic learning and PAS can be actively trained, as has been successfully shown in behavioral activation and related treatment approaches for anhedonia (Craske et al., 2016; Fancourt et al., 2020; Nagy et al., 2020), which can also be delivered remotely (Huguet et al., 2018). As the COVID-19 pandemic impacts mental health (Henssler et al., 2020; Pan et al., 2021; Peters et al., 2020), strengthening state hedonic capacity and hedonic learning combined with PAS may be a preventive strategy that can smoothly be integrated into everyday life.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Contributors

All authors made a substantial contribution to the work, drafted or revised the manuscript, and approved it. Specific contributions were to study design: A.D., S.A.W., H.W.; to survey generation and study conduct/data collection: A.D., S.A.W.; to data analysis: A.D., S.A.W.; and to writing: A.D., S.A.W., H.W.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jadr.2021.100200.

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