Original Article

Prediction of Changes in Negative Affect During the COVID-19 Pandemic by Experimental Fear Conditioning and Generalization Measures

A Longitudinal Study

Celina Imholze[1], Katharina Hutterer[1], Dominik Gall[1], Udo Dannlowski[2], Katharina Domschke[3,4], Elisabeth J. Leehr[2], Tina B. Lonsdorf[5], Ulrike Lueken[6], Andreas Reif[7], Karoline Rosenkranz[5], Miriam A. Schiele[3], Peter Zwanzger[8,9], Paul Pauli[1], and Matthias Gamer[1]

[1]Department of Psychology, Julius Maximilians University of Würzburg, Germany
[2]Institute for Translational Psychiatry, University of Münster, Germany
[3]Department of Psychiatry and Psychotherapy, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Germany
[4]Center for Basics in Neuro-Modulation, University of Freiburg, Germany
[5]Institute for Systems Neuroscience, University Medical Center Hamburg Eppendorf, Germany
[6]Department of Psychology, Humboldt-Universität zu Berlin, Germany
[7]Department of Psychiatry, Psychosomatic Medicine and Psychotherapy, University Hospital Frankfurt – Goethe University, Frankfurt am Main, Germany
[8]Kbo Inn Salzach Hospital Clinical Center for Psychiatry, Wasserburg am Inn, Germany
[9]Department of Psychiatry, LMU Munich, Munich, Germany

Abstract: Adverse experiences interact with individual vulnerability in the etiology of mental disorders, but due to the paucity of longitudinal studies, their precise interplay remains unclear. Here, we investigated how individual differences in threat responsiveness modulated adjustments in negative affect during the COVID-19 pandemic. Participants (N = 441) underwent a fear conditioning and generalization experiment between 2013 and 2020 and were reassessed regarding anxiety and depression symptoms after the pandemic outbreak. Participants showed increased levels of negative affect following pandemic onset, which were partly modulated by laboratory measures of threat responsiveness. Decreased differentiation of threat and safety signals in participants with higher prepandemic depression and anxiety scores in the laboratory assessment were most predictive of increased symptom levels after the onset of the pandemic. However, effects were small and should be replicated in independent samples to further characterize how individual differences in threat processing interact with adverse experiences in the development of psychopathology.

Keywords: COVID-19, fear conditioning, generalization, negative affect, longitudinal

Adaptive responses triggered by fear are vital for human survival, whereas nonadaptive and irrational fears are the main features of anxiety disorders, which represent the most common class of mental disorders (Kessler et al., 2005). Understanding temporal trajectories in the development of maladaptive fears might help to find strategies to counter such mental problems. Current theories point to an interaction of individual predispositions with adverse experiences in the etiology of anxiety disorders (Gross & Hen, 2004). In recent years, it has been suggested that overgeneralization of

conditioned fear might be a particularly relevant vulnerability factor (Dymond et al., 2015).

Previous research on clinical samples indeed provided behavioral and psychophysiological evidence for an overgeneralization of conditioned fear in anxiety patients as compared to healthy controls (for a review, see Fraunfelter et al., 2022). In many studies, participants learned to fear a ring of a certain size (conditioned threat stimulus, CS+) that predicted a threat (i.e., the unconditioned stimulus, US), but not a ring of a different size that was never followed by the US (conditioned safety stimulus, CS−). In the subsequent generalization phase, eight other rings (generalization stimuli, GS) were presented in addition to the CS, ranging in size between CS+ and CS−. None of the GS was paired with the US. Nevertheless, both patients with panic disorder (Lissek et al., 2010) and those with generalized anxiety disorder (Lissek et al., 2014) responded with fear to a wider range of generalization stimuli (GS) on the physiological level (i.e., startle responses) and on the level of subjective ratings (i.e., US expectancy) than healthy control participants. Fear responses of patients extended even to stimuli that were more similar to the CS−, a phenomenon referred to as overgeneralization of conditioned fear (Lissek et al, 2010). Although such overgeneralization was not found in every study (e.g., Tinoco-González et al., 2015) and not for all anxiety disorders (e.g., Ahrens et al., 2016), it was hypothesized that such differences in threat responsiveness might constitute a vulnerability factor for the development of anxiety disorders (Struyf et al., 2015).

More recently, Stegmann et al. (2019) suggested that one reason for the lack of convergent results in this field of research may be related to the exclusive focus on fear generalization and the corresponding neglect of other, more basic characteristics of threat responsiveness. Specifically, they analyzed data of a large group of healthy individuals and identified several clusters of participants who did not only differ in fear generalization but also in average fear responses to all stimuli that were used in the experiment as well as the differentiation between conditioned threat and safety signals. Importantly, the latter two aspects could already be identified during the acquisition of conditioned fear, and specifically, the average fear response was related to psychometric measures of fear. These data showed that threat responsiveness needs to be examined more comprehensively, and the authors hypothesized that in line with the assumption of a dimensional psychopathology, such interindividual differences may constitute potential risk factors for the pathogenesis of anxiety disorders (Insel et al., 2010).

As described above, enhanced vulnerability might not necessarily lead to the etiology of an anxiety disorder. However, environmental factors or traumatic experiences can promote such development (Gross & Hen, 2004). This could also be the case for epidemics or pandemics that were shown to have a significant impact on mental health (Gardner & Moallef, 2015; Hong et al., 2009; Jeong et al., 2016), yet little empirical evidence is available on how risk factors and adverse experiences interact in the development of anxiety symptoms. This is partly because environmental influences are difficult to control for large samples, and meaningful study designs are complex and costly. The COVID-19 pandemic – despite all of its negative consequences – represents an exceptional opportunity to study the impact of stressful life events on mental health. Across the globe, large parts of the population face(d) social isolation and special hygiene measures, experience(d) severe economic damage, and are/were possibly confronted with health restrictions or even the loss of close friends or family members.

Since the beginning of the COVID-19 pandemic, several studies have investigated predictors of mental health in general or the development of anxiety disorders in particular. However, these studies were often limited to the analysis of demographic characteristics as potential risk factors and mostly implemented cross-sectional study designs. For example, Cao et al. (2020) interviewed college students and found that having relatives or acquaintances suffering from COVID-19, experiencing negative economic effects and impacts on their daily life, as well as delays in their academic activities due to the pandemic were risk factors for increased anxiety. Hein et al. (2021) further showed that trait anxiety, social factors (e.g., fear of loneliness), and uncertainty (e.g., uncertainty to master the crisis) predicted the amount of negative affect at the beginning of the pandemic. Other studies identified sociodemographic characteristics like female gender, higher age, being married, having children, living in urban areas as well as illness history, COVID-19-related protective behaviors, and anxious beliefs as risk factors for higher coronavirus-related anxiety (Hilbert et al., 2022; Malesza & Kaczmarek, 2020; Özdin & Bayrak Özdin, 2020). A study in the context of the previous MERS-CoV epidemic furthermore revealed that social isolation and uncertainty, both in healthy individuals and those with pre-existing mental health problems, results in increased negative affect (Jeong et al., 2016), and a 4-year follow-up of SARS-CoV-1 survivors reported that 44% of subjects developed a post-traumatic stress disorder (Hong et al., 2009). Other studies on the SARS epidemic have reported similar findings (Gardner & Moallef, 2015).

A recent meta-analysis of longitudinal cohort studies comparing mental health before versus during the COVID-19 pandemic revealed an overall increase in mental health symptoms after the onset of the pandemic that decreased and returned to prepandemic levels by mid-2020 (Robinson et al., 2022; see also COVID-19 Mental Disorders Collaborators, 2021). Increases in depression and

mood disorder symptoms tended to be larger and more stable than increases in anxiety and general mental health symptoms. However, the authors reported a high degree of unexplained heterogeneity indicating a high variability across samples. In accordance with this heterogeneity, a study of Beutel et al. (2021) reported increased levels of depression and anxiety symptoms after the onset of the pandemic in Germany, whereas a longitudinal study of Kwong et al. (2021) in the United Kingdom observed similar levels of depression compared to a prepandemic assessment but increased anxiety during the pandemic. Finally, a third study by Yarrington et al. (2021) in the United States reported different temporal profiles for anxiety and depression symptoms during the pandemic. Anxiety increased during the acute phase after the onset (i.e., first month) but leveled off later with values returning to baseline again (i.e., prepandemic values). Depression symptoms, however, showed a slower increase and significantly higher values were observed in the months directly following the acute phase.

Taken together, it seems clear that the COVID-19 pandemic is imposing an enormous burden on mental health and in particular on symptoms of anxiety and depression. However, it is less evident to what extent vulnerability factors in the general population – such as overgeneralization of anxiety – influence these changes in mental health. Thus, there is a need for large-scale longitudinal studies that combine measures of fear responsiveness with changes in negative affect during such adverse experiences. The present study attempts to fill this gap by examining how individual differences in threat responsiveness shape adjustments in negative affect during the COVID-19 pandemic. Importantly, this also allows us to examine the predictive value of experimental fear conditioning and generalization measures on negative affect. Such validation of potential risk factors is still pending due to a lack of well-powered longitudinal studies (Scheveneels et al., 2021). Here, we relied on experimental laboratory data from a large healthy sample that underwent a differential fear acquisition and generalization paradigm before the onset of the pandemic (Schiele et al., 2016). We assessed the modulating influence of subjective and autonomic characteristics of threat responsiveness on changes in self-report questionnaires regarding anxiety and depression during the pandemic. We hypothesized participants to show elevated negative affect after the onset of the pandemic and explored whether these changes were related to individual differences in general threat responding, fear acquisition, and generalization. Since previous work showed more robust individual differences in general threat responding as compared to measures of threat differentiation and generalization (Stegmann et al., 2019), we also expected a larger influence of such general indices on negative affect in the current study. Moreover, larger effects were hypothesized for subjective as compared to autonomic measures (cf., Reutter & Gamer. 2022).

Methods

Participants

For the current study, we relied on a well-characterized sample of 1,135 healthy participants who were examined between May 2013 and beginning of March 2020[1] within the Collaborative Research Center Fear, Anxiety, Anxiety Disorders (CRC-TRR-58, project Z02) at the universities of Würzburg and Hamburg. All participants fulfilled general inclusion criteria (male or female sex, age between 18 and 50 years) that were checked prior to participation in a telephone interview. Exclusion criteria included left-handedness; non-Caucasian descent; intake of psychoactive medication; excessive consumption of alcohol, nicotine, and caffeine; consumption of illegal drugs; severe medical diseases; or pregnancy. The absence of a current or lifetime diagnosis of a mental disorder (DSM-IV Axis-I) at the time of the laboratory assessment (T0) was assessed by the German version of the Mini International Psychiatric Interview (Sheehan et al., 1998). Drug abstinence and pregnancy were tested using urine screening tests. These participants were contacted by e-mail on September 09, 2020, and asked to complete an online questionnaire using individualized links. For the laboratory study, participants were paid 50 € and they additionally received 20 € for the questionnaire. In total, 575 participants completed the online questionnaire between September 15, 2020, and October 29, 2020. From this sample, we had to exclude 11 participants due to incomplete data and 123 participants because of electrodermal non-responsivity (see criteria below). Thus, the final sample consisted of 441 participants (286 female, 155 male) aged between 18 and 50 years (M = 24.96 years, SD = 5.91 years).

The first measurement (T0) took place before the onset of the COVID-19 pandemic in the laboratories of the involved universities and included both questionnaire and experimental data collection (see Figure 1; cf. Schiele et al.,

[1] Please note that although the pandemic already reached Europe at the beginning of 2020, severe restrictions of the public life in Germany started later. For example, school and kindergarten closures were mandated from 13.03.2020, borders to other European countries were closed on 15.03.2020, and curfews (i.e., "lockdowns") were imposed in six German states on 22.03.2020. Other states prohibited close contact with persons from outside one's household at the same time.

Figure 1. Illustration of the study protocol and the design of the fear conditioning and generalization experiment. In the acquisition phase, one stimulus (CS+) was followed by a loud scream with the face showing a fearful expression or nothing (CS−). In the generalization phase, participants additionally saw face morphs between the two initial faces. Arousal ratings were assessed after each block of the different phases, and skin conductance was recorded continuously during the whole experiment. Please note that the face stimuli that were used in the actual experiment differ from this illustration. Due to copyright restrictions, we cannot show the blonde women here and show a redhead woman instead.

2016; Stegmann et al., 2019). The second collection of questionnaire data (T1) was conducted during the pandemic from September 2020 to October 2020 using an online follow-up survey (Figure 1). At that time, public life was severely disrupted in Germany due to pandemic containment measures like social distancing. Furthermore, vaccines were not yet available. The average time lag between T0 and T1 was M = 4.62 years (SD = 2.34 years).

Questionnaires

At both time points, participants completed a series of sociodemographic and psychological questionnaires. To assess negative affect, we selected the German versions of the State-Trait Anxiety Inventory (STAI-T; Laux et al., 1981), the Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990), the Center for Epidemiologic Studies Depression Scale (CES-D,

Hautzinger & Bailer, 1993), as well as the Anxiety Sensitivity Index-3 (ASI; Kemper et al., 2009).

Experimental Design and Procedure

In the laboratory experiment conducted prepandemic, participants underwent a differential fear conditioning and generalization paradigm adapted from Lau et al. (2008) which is illustrated in Figure 1 (cf. Schiele et al., 2016). In this experiment, faces of a brunette and a blond woman with neutral facial expression (03F_NE_C and 10F_NE_C, NimStim Face Stimulus Set, Tottenham et al., 2009) served as *conditioned stimuli* (CS). One face stimulus (CS+) could directly be followed by the aversive *unconditioned stimulus* (US), while the other face (CS−) was never followed by the US. The US was a fearful facial expression of the woman serving as CS+, simultaneously presented with a 95 dB loud female scream (FemScream2, no. 276, International Affective Digitized Sounds, Bradley & Lang, 1999) for 1.5 s at the offset of CS+. Four gradual morphs of the CSs were created in 20% steps by means of the dedicated software Squirlz Morph (version 2.1, Xiberpix, Solihull, UK; for details, see Schiele et al., 2016) and used as *generalization stimuli* (GS).

All stimuli were presented using Presentation software version 16.0 (Neurobehavioral Systems, Inc., Albany, CA). Participants were instructed to attend to the pictures, and they were forewarned that they would occasionally hear an unpleasant loud noise, but the CS-US contingency was not revealed. Assignment of stimuli to CS+ or CS− was randomized across participants. CSs and GSs were each presented for 6 s and in a pseudorandomized order so that the same stimulus appeared no more than twice in succession. During the intertrial interval (random duration between 9 and 12 s), a white fixation cross was displayed in the center of the screen.

The experiment included three phases (see Figure 1). During the *habituation phase*, both the CS+ and the CS− were presented four times each without any US. *Acquisition phase* and *generalization phase* were both divided into two identical blocks in which each stimulus was presented six times. During acquisition blocks, the US was presented in five trials after CS+ offset (83% reinforcement rate) and never after CS−. During generalization blocks, the US continued to be delivered in three CS+ trials (50% reinforcement rate) to prevent rapid extinction of conditioned fear. Parts of the sample completed a discrimination training between generalization blocks, which is why the current analyses are based on only the first block of the generalization phase.

During the experiment, skin conductance was measured continuously. Moreover, after each block, participants rated arousal ("*how much stress/tension/arousal was triggered by this picture?*") and valence ("*how pleasant* vs. *unpleasant was the picture for you?*") of each stimulus on Likert scales ranging from 1 ("calm" or "very unpleasant") to 9 ("intense" or "pleasant"). For the acquisition and generalization phase, US-expectancy ratings ("*how likely do you expect to hear the scream with this picture?*") were additionally recorded using a Likert scale ranging from 0 ("very unlikely") to 100 ("very likely") in increments of 10. The facial stimuli were rated in a fixed order (brunette woman, blonde woman, morphs from brunette to blonde) and were each presented for 1 s before the Likert scale appeared.

Physiological Recordings and Data Reduction

Skin conductance was recorded from the thenar and hypothenar eminences of the left hand with Ag/AgCl electrodes. Brainproducts V-Amp and BrainVision Recorder software (version 1.21, Brainproducts, Gilching, Germany) were used for recording with a sampling rate of 1,000 Hz and an online notch filter of 50 Hz. Offline analyses were performed using BrainVision Analyzer software (version 2.1, Brainproducts, Gilching, Germany) after low-pass filtering with a cutoff frequency of 1 Hz. In accordance with common guidelines (Boucsein et al., 2012), amplitudes of skin conductance responses (SCRs) were defined as the difference in μS between response onset and peak. The response onset was defined as the minimal value 900–4,000 ms after stimulus onset and the peak as the subsequent maximum value 2000–6,000 ms after stimulus onset. Reactions smaller than 0.02 μS were set to 0. Then, each participant's response was range-corrected (i.e., divided by the participant's strongest response to a facial stimulus) and log-transformed to reduce the skew of the amplitude distribution. Lastly, mean values were calculated for each stimulus and experimental block. Since low electrodermal responding (e.g., related to quick habituation) might substantially affect the stability and robustness of the currently used measures of threat responsiveness, we decided to use a rather strict exclusion criterion for electrodermal non-responding (cf. Lonsdorf et al., 2019). Participants ($N = 125$, see above) with an overall raw mean response smaller than 0.02 μS were excluded from the sample (see the Electronic Supplementary Material, ESM 1, for an analysis of the full sample with valid data).

Statistical Analysis

To characterize participants regarding negative affect, we followed the suggestion of Baumann et al. (2017) and aggregated the questionnaire data into two factors characterizing individual differences in anxiety (ASI) and

depression (STAI-T, PSWQ, and CES-D). For this purpose, questionnaires belonging to the depression factor were *z*-standardized across time points and then averaged separately for T0 and T1. This approach was substantiated by the pattern of correlations between questionnaire scores and the results of a confirmatory factor analysis (see "Aggregation of questionnaire data" and Table E4 in ESM 1).

For the fear acquisition and generalization paradigm, we relied on arousal ratings as a subjective response and skin conductance responses (SCRs) as an objective measure of threat responsiveness. Since we aimed to reduce the number of statistical tests in this rather exploratory study, we decided to focus on only one subjective measure (for a similar procedure, see Stegmann et al., 2019). All ratings were substantially correlated, but mutual correlations with the other two constructs were largest for arousal as compared to valence and US-expectancy ratings (see ESM 1, Table E5). Thus, in the current study, arousal ratings seemed to be best suited to comprehensively describe threat responding on the subjective level. From arousal ratings and skin conductance response (SCR) amplitudes, we calculated three indices to estimate individual differences in fear responses: (1) the general threat responsiveness as the arithmetic mean of all responses, (2) the differentiation between threat and safety as the difference between CS+ and CS−, and (3) the linear deviation score ($\mathrm{LDS} = \mathrm{Mean}(\mathrm{CS}+, \mathrm{CS}-) - \mathrm{Mean}(\mathrm{GS1}, \mathrm{GS2}, \mathrm{GS3}, \mathrm{GS4})$; cf. Kaczkurkin et al., 2017) as an index of fear generalization, with higher values indicating a steeper gradient and less fear generalization.

To assess changes in negative affect during the pandemic, we first used repeated measures analyses of covariance (ANCOVAs) to compare anxiety and depression scores between T0 and T1 while taking the time lag between measurements into account. Generalized η^2 values are reported as effect size estimates. To further examine the influence of individual differences in threat responsiveness on these changes, we computed several linear regression models. Measures of anxiety and depression at T1 served as a criterion and comparable assessments at T0 as predictors. We additionally included measurements of general threat responsiveness, CS differentiation, and fear generalization from the experimental laboratory task as well as interactions between these indices and participants' baseline measures into the models. The time lag between T0 and T1 was included as a control variable. Since analyses were done separately for the acquisition and the generalization phase and included objective (SCRs) as well as subjective measures (arousal ratings), a total of eight regression models was computed. All calculations were accomplished in the R software environment (version 4.1.3, https://www.r-project.org) on a significance level of $\alpha = .05$.

Results

As expected, ratings of anxiety, $F(1, 438) = 99.95$, $p < .001$, $\eta^2 = .186$, and depression, $F(1, 438) = 186.68$, $p < .001$, $\eta^2 = .299$, increased after the onset of the pandemic with small-to-medium effect sizes (see Figure 2). The time lag between measurements did not affect these changes ($p > .13$, $\eta^2 < .01$).

The different indices of threat responsiveness that were derived from the data acquired in laboratory experiment before the onset of the pandemic showed a substantial variability in the current sample (see Table 1). The linear regression models to explore whether these measures might affect changes in anxiety and depression ratings from before to during the pandemic revealed the following findings: First, across all models, prepandemic scores predicted anxiety and depression during the pandemic (see Tables 2 and 3). Thus, the ranks of individual participants on these measures remained rather stable during the years from T0 to T1. Second, we obtained significant main effects of CS differences in arousal ratings during the acquisition and generalization phase as well as significant interaction effects of these values with prepandemic scores on depression ratings during the pandemic. Thus, higher depression levels during the pandemic were predicted by reduced CS differentiation, and this effect was significantly enhanced for participants who had higher baseline depression scores (see Figure 3A and B). Third, we observed a significant interaction effect of average arousal ratings after the acquisition phase and prepandemic depression ratings on corresponding scores at T1 such that subjects with high levels of depression who exhibited a lower general threat responsiveness reported significantly higher depression values at T1 (see Figure 3C). Finally, we obtained a significant interaction effect of anxiety scores at T0 with the CS differentiation in SCRs during the acquisition phase on anxiety ratings at T1. This indicates that highly anxious participants who showed a poorer ability to differentiate between CS+ and CS− reported disproportionately higher anxiety levels at T1 (see Figure 3D). Across all analyses, the length of the time period between T0 and T1 did not have a significant effect on changes in negative affect (see Tables 2 and 3).

Discussion

This exploratory longitudinal study examined how laboratory fear acquisition and generalization measures shape adjustments in negative affect during the course of the COVID-19 pandemic. One major goal was to elucidate whether experimental measures of fear allow for

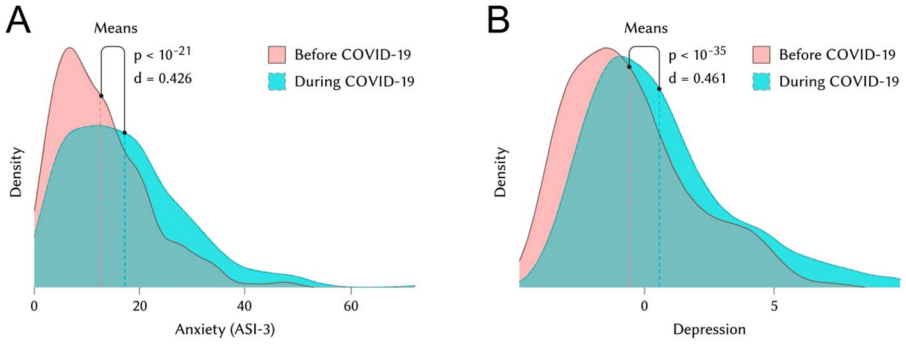

Figure 2. Participants reported increased anxiety (A) and depression (B) during the COVID-19 pandemic compared to before the pandemic. Effect sizes are reported as Cohen's *d*. ASI-3 = Anxiety Sensitivity Index-3.

Table 1. Descriptive statistics of the different measures of threat responsiveness

		Arousal ratings				SCR amplitudes			
Phase	Measure	*M*	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*
Acquisition	M_{Resp}	4.58	1.37	1.00	8.50	0.05	0.03	0.00	0.15
	CS_{Diff}	3.06	2.32	−3.50	8.00	0.01	0.03	−0.01	0.11
Generalization	M_{Resp}	4.22	1.59	1.00	8.83	0.03	0.03	0.02	0.14
	CS_{Diff}	3.42	2.40	−6.00	8.00	0.02	0.04	0.00	0.18
	LDS	0.42	1.21	−5.00	6.00	0.01	0.02	−0.04	0.08

Note. M_{Resp} = average threat responses across stimuli of the respective phase; CS_{Diff} = differentiation between CS+ and CS−; LDS = linear deviation score as a measure of fear generalization.

predicting changes in negative affect in response to adverse events and therefore might reflect risk factors for psychopathology (Scheveneels et al., 2021).

The current analyses relied on a comparably large sample of participants who were healthy when completing the initial laboratory assessment. These participants underwent a fear acquisition and generalization paradigm before the onset of the pandemic (Schiele et al., 2016) and were reassessed in 2020 when public life was severely disrupted in Germany due to several pandemic containment measures and the unavailability of vaccines and pharmacological treatments at that time. Unlike comparable studies (e.g., Malesza & Kaczmarek, 2020; Özdin & Bayrak Özdin, 2020), we had access to baseline data on anxiety and depression that were acquired before the onset of the COVID-19 pandemic, and we could examine changes in these measures due to the pandemic as well as the potential modulating effects of laboratory measures of fear on these adjustments.

As hypothesized, we observed an increase in participants' anxiety and depression scores after the onset of the pandemic and the length of the time interval between both measurements did not have an effect. These scores were also predicted by prepandemic values indicating that although negative affect increased in general, the ranks of individual participants on these measures remained rather stable during the years. These results complement previous studies and demonstrate a significant negative influence of the pandemic on mental health (Beutel et al., 2021; Hunt et al., 2022; Kwong et al., 2021; Robinson et al., 2022). It is less clear, however, how stable these findings are in the long run. For example, it has been shown that anxiety levels rose quickly after the onset of the pandemic but also tended to decrease again only one month later whereas depression showed a delayed but potentially also more stable increase (Yarrington et al., 2021). To examine such temporal profiles with higher precision, longitudinal studies with a larger number of data collection points are highly desirable.

Although all participants of the current study were free from mental illness (i.e., they had no current or lifetime diagnosis of a mental disorder) at T0, they showed a relatively large variability in measures of threat responsiveness during the fear acquisition and generalization paradigm that was accomplished in the laboratory prior to the onset of the COVID-19 pandemic. Interestingly, changes in negative affect during the pandemic were partly modulated by these indices of threat responsiveness. Thus, highly anxious participants who showed a reduced electrodermal differentiation between CS+ and CS− reported disproportionately higher anxiety levels during the pandemic. Comparable effects were also observed for depression scores, where higher depression levels during the pandemic were predicted by reduced CS differentiation, and this effect was significantly larger for participants who had higher baseline depression scores. Finally, subjects with high levels of depression who exhibited

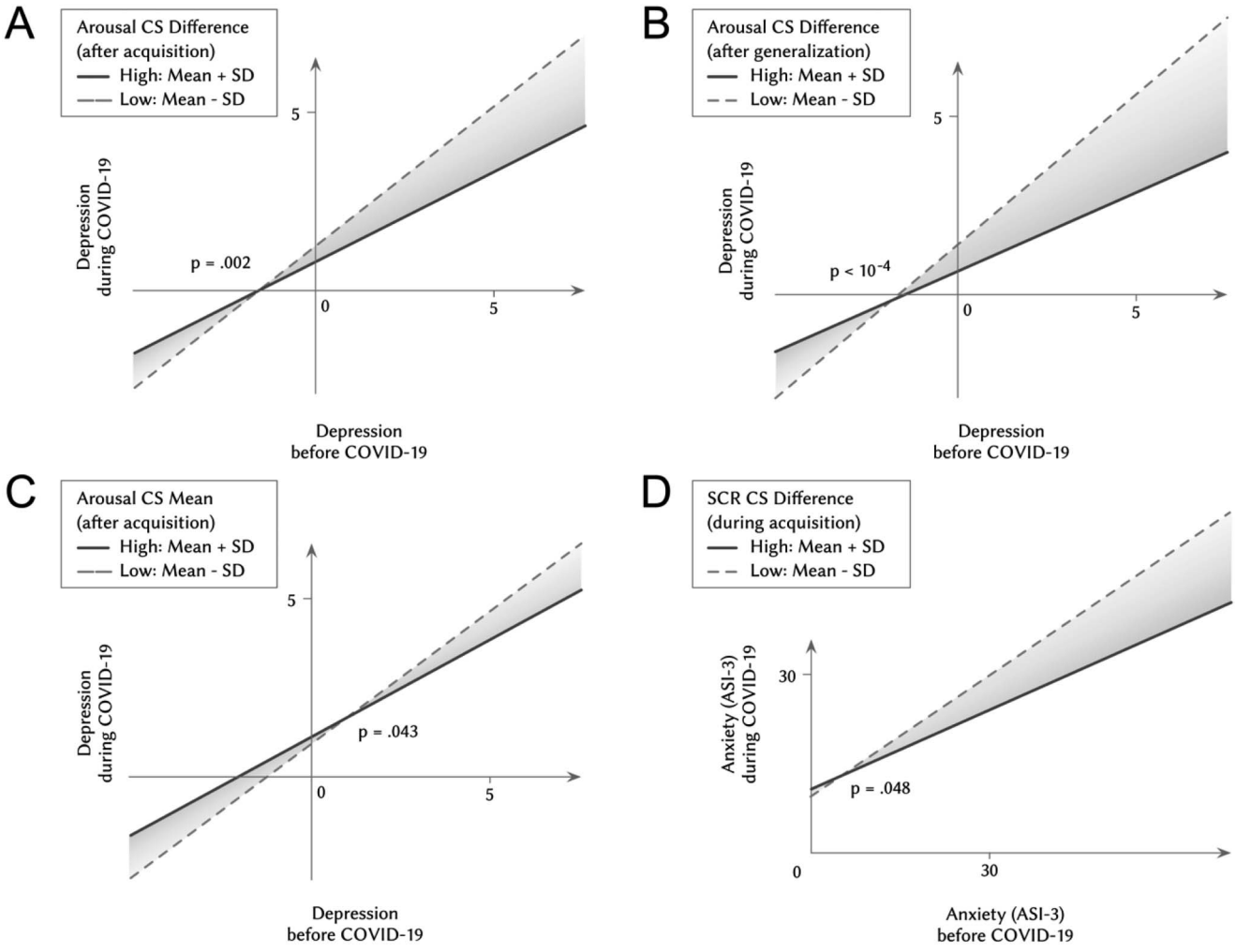

Figure 3. Illustration of the observed interaction effects between questionnaire scores at T0 and laboratory measures of threat responsiveness on depression and anxiety values at T1. All panels exemplarily depict groups with low (*M* − *SD*, dashed line) and high values (*M* + *SD*, solid line) of the relevant measures. (A) and (B) show the interaction of depression scores at T0 and CS−differences in arousal during the acquisition and generalization phase; (C) depicts a similar interaction with average arousal ratings after the acquisition phase; (D) illustrates the interaction of anxiety scores at T0 with the CS−differentiation in skin conductance response (SCR) amplitudes on anxiety levels at T1. ASI-3 = Anxiety Sensitivity Index-3.

a lower general threat responsiveness reported significantly higher values after the outbreak of the COVID-19 pandemic.

These findings are noteworthy for three reasons: First, although fear acquisition and generalization are frequently assumed to constitute specific risk factors for anxiety psychopathology (e.g., Kindt, 2014; Lissek et al., 2010), we observed larger effects on depression than on anxiety scores – at least for subjective arousal ratings. This could be related to the current assessment including several questionnaires for measuring depressive symptoms (PSWQ, STAI-T, CES-D) as compared to only one questionnaire for anxiety psychopathology (ASI). This procedure followed suggestions by Baumann et al. (2017) that the currently used questionnaires primarily load on different factors for anxiety and depression, but it neglects that both constructs overlap substantially (e.g., the STAI was included into the depression factor here but was originally developed for measuring trait anxiety, Laux et al., 1981). Moreover, depressive symptoms were assessed more comprehensively in the current study than anxiety psychopathology. It thus seems possible that the currently observed results rather reflect a general influence of the different laboratory measures on changes in negative affect than specific effects on depression and anxiety. Therefore, future studies including a broader set of questionnaires and clinical data on depression and anxiety symptoms seem desirable.

Second, larger effects were observed for measures of threat responsiveness on the level of subjective evaluation (i.e., arousal ratings) as compared to physiological data (i.e., SCR amplitudes, cf. Stegmann et al., 2019). Although this finding might indicate a genuine difference between subjective and objective indices of fear acquisition and generalization on changes in negative affect during the pandemic, it could also be related to methodological

Table 2. Regression models of T0 scores and experimental threat responsiveness measures during the acquisition phase on anxiety and depression ratings at T1

	Anxiety		Depression	
	Arousal ratings	SCR amplitudes	Arousal ratings	SCR amplitudes
Coefficients	R_{adj}^2 = .18	R_{adj}^2 = .19	R_{adj}^2 = .32	R_{adj}^2 = .29
T0 scores	0.700***	0.319***	0.995***	0.563***
M_{Resp}	0.095	−0.122	0.035	0.010
CS_{Diff}	0.129	0.045	−0.081*	−0.056
T0 scores × M_{Resp}	−0.202	0.213	−0.299*	−0.023
T0 scores × CS_{Diff}	−0.154	−0.162*	−0.203**	0.009
Time delay	0.068	0.067	0.057	0.058

Note. Standardized model estimates are reported for all coefficients of the respective linear regression model; adjusted R^2 values are reported as an indicator of model fit; M_{Resp} = average threat responses across CS+ and CS−; CS_{Diff} = differentiation between CS+ and CS−; *p < .05. **p < .01. ***p < .001.

Table 3. Regression models of T0 scores and experimental threat responsiveness measures during the generalization phase on anxiety and depression ratings at T1

	Anxiety		Depression	
	Arousal ratings	SCR amplitudes	Arousal ratings	SCR amplitudes
Coefficients	R_{adj}^2 = .20	R_{adj}^2 = .18	R_{adj}^2 = .33	R_{adj}^2 = .29
T0 scores	0.524***	0.324***	0.875***	0.617***
M_{Resp}	0.099	−0.123	−0.017	−0.011
CS_{Diff}	−0.046	0.050	−0.133**	−0.010
LDS	−0.143	−0.035	−0.080	−0.002
T0 scores × M_{Resp}	−0.070	0.219	−0.103	−0.100
T0 scores × CS_{Diff}	−0.072	−0.023	−0.292***	0.023
T0 scores × LDS	0.069	−0.022	0.046	0.002
Time delay	0.071	0.068	0.044	0.063

Note. Standardized model estimates are reported for all coefficients of the respective linear regression model; adjusted R^2 values are reported as an indicator of model fit; M_{Resp} = average threat responses across all stimuli of the generalization phase; CS_{Diff} = differentiation between CS+ and CS−; LDS = linear deviation score as a measure of fear generalization; **p < .01. ***p < .001.

aspects regarding the measurement of these data (e.g., ratings and questionnaires both required a cognitive elaboration and were thus potentially more correlated) or the lower reliability and manifold methods for the analysis of physiological responses in such paradigms (Zeidan et al., 2012). Moreover, it seems possible that autonomic measures of threat responsiveness have higher predictive value for physiological stress responses during the pandemic that were not acquired in the current study. Using measures of ambulatory assessment (Trull & Ebner-Priemer, 2013), such studies seem possible in the future and should be considered to comprehensively assess psychopathology on the subjective and objective level.

Third, whereas we observed relatively consistent effects of CS− differentiation on adjustments in negative affect, specific measures of fear generalization (i.e., the shape of the generalization gradient as summarized by the LDS, cf. Kaczkurkin et al., 2017) did not predict changes in depression or anxiety levels. Although these findings are surprising at first glance given the assumed relevance of fear generalization for psychopathology (Kindt, 2014), they are consistent with recent research (Stegmann et al., 2019) indicating that specific measures of fear generalization might be less relevant for anxiety and depression psychopathology than overall measures of threat responsiveness and fear acquisition. Furthermore, the currently observed detrimental effects of a reduced CS− differentiation on anxiety and depression levels could also be interpreted within the generalization framework since comparable responses to CS+ and CS− also indicate reduced stimulus discrimination and thus reflect increased generalization. However, this observation calls into question whether an elaborate assessment of fear generalization including a larger number of generalization stimuli is necessary when comparable effects concerning CS+ and CS− are already evident at the end of the fear acquisition phase (Stegmann et al., 2019).

The current findings match observations in clinical samples suggesting that anxiety patients typically show

elevated responses to safety signals (i.e., the CS− in the current experimental scenario) and correspondingly a reduced differentiation between threat and safety cues (Duits et al., 2015; Lissek et al., 2005). Such tendency was also found to be maladaptive in the current sample and predicted increased negative affect after the onset of the COVID-19 pandemic specifically in those participants who had higher baseline values. Although other studies on smaller samples partly yielded divergent results (e.g., Hunt et al., 2022), the current study demonstrated that certain laboratory measures of threat responsiveness seem to be suitable to predict changes in mental strain following adverse experiences.

In addition to the influence of CS− differentiation, we also found that the general response level had predictive value for changes in depression scores during the pandemic. This observation might indicate a more negative development of participants with low depression values before the onset of the pandemic who showed large responses to all stimuli in the fear conditioning experiment.

The present study has several strengths including the reliance on longitudinal data from a large sample with a baseline assessment prior to the COVID-19 pandemic outbreak. However, some limitations should also be acknowledged. First, the current sample underwent the initial laboratory assessment during a relatively long period from May 2013 to March 2020. It thus seems conceivable that T0 measures do not consistently reflect a specific prepandemic time point but rather vary regarding their representativeness between participants. To take this possibility into account, we included this variable into all analyses but did not observe a significant effect in any of the models. Second, the current sample was relatively homogenous regarding age, education, and Caucasian descent, and participants were very healthy due to strict inclusion criteria. As a result, they showed more moderate threat responsiveness compared to anxiety patients (e.g., Lissek et al., 2010, 2014) and were potentially also more resilient to negative experiences during the COVID-19 pandemic. Therefore, future studies should also examine how measures of threat responsiveness and negative experiences interact in adaptations of negative affect in more diverse (sub)clinical samples. Such studies should ideally also include individual differences in how the adverse situation is actually perceived. In the current study, we did not acquire stress ratings or comparable measures and had to rely on changes in standard questionnaires. A more detailed assessment of individual stress levels in future studies is thus desirable. Third, we did not measure the aversiveness of the currently used US (the loud female scream) in the experimental laboratory paradigm. Comparable stimuli have been used in previous fear conditioning studies (e.g., Baumann et al., 2017; Haddad et al., 2013; Schiele et al., 2016) and seem to be more aversive than other sounds or air puffs (Lau et al., 2008). However, it seems important to explicitly examine the influence of US aversiveness on fear acquisition and generalization in future studies. Fourth, in order not to lose statistical power, we did not adjust alpha levels for multiple testing. We therefore strongly suggest replicating the current findings in independent samples.

Conclusion

To the best of our knowledge, the present study on a relatively large and well-characterized sample is the first exploratory longitudinal study to examine the predictive value of laboratory fear acquisition and generalization measures on changes in negative affect in the context of the COVID-19 pandemic. As hypothesized, we observed an increase in participants' anxiety and depression scores after the onset of the pandemic. These adaptations were partly modulated by measures of general threat responsiveness and the differentiation of threat and safety signals. Surprisingly, although fear acquisition and generalization are assumed to constitute risk factors for anxiety psychopathology, we observed larger effects on depression than on anxiety scores – at least for subjective arousal ratings. Moreover, measures of fear generalization neither predicted changes in depression nor in anxiety levels. These findings complement recent research (Stegmann et al., 2019), but effects were rather small on average and should be replicated in independent samples to further elucidate how individual differences in threat processing interact with adverse experiences in the development of psychopathology.

Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at https://doi.org/10.1027/2151-2604/a000523.

ESM 1. Table E4: Correlations of questionnaires. Table E5: Correlations between arousal, valence, and US-expectancy ratings

References

Ahrens, L. M., Pauli, P., Reif, A., Mühlberger, A., Langs, G., Aalderink, T., & Wieser, M. J. (2016). Fear conditioning and stimulus generalization in patients with social anxiety disorder. *Journal of Anxiety Disorders*, *44*, 36–46. https://doi.org/10.1016/j.janxdis.2016.10.003

Baumann, C., Schiele, M. A., Herrmann, M. J., Lonsdorf, T. B., Zwanzger, P., Domschke, K., Reif, A., Deckert, J., & Pauli, P.

(2017). Effects of an anxiety-specific psychometric factor on fear conditioning and fear generalization. *Zeitschrift Für Psychologie*, *225*(3), 200–213. https://doi.org/10.1027/2151-2604/a000304

Beutel, M. E., Hettich, N., Ernst, M., Schmutzer, G., Tibobus, A. N., & Braehler, E. (2021). Mental health and loneliness in the German general population during the COVID-19 pandemic compared to a representative pre-pandemic assessment. *Scientific Reports*, *11*(1), Article 14946. https://doi.org/10.1038/s41598-021-94434-8

Boucsein, W., Fowles, D. C., Grimnes, S., Ben-Shakhar, G., Roth, W. T., Dawson, M. E., Filion, D. L., & Society for Psychophysiological Research Ad Hoc Committee on Electrodermal Measures (2012). Publication recommendations for electrodermal measurements. *Psychophysiology*, *49*(8), 1017–1034. https://doi.org/10.1111/j.1469-8986.2012.01384.x

Bradley, M. M., & Lang, P. J. (1999). *International Affective Digitized Sounds (IADS): Stimuli, Instruction Manual and Affective Ratings* [Technical Report B-2]. The Center for Research in Psychophysiology, University of Florida.

Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., & Zheng, J. (2020). The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Research*, *287*, Article 112934. https://doi.org/10.1016/j.psychres.2020.112934

COVID-19 Mental Disorders Collaborators (2021). Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet*, *398*(10312), 1700–1712. https://doi.org/10.1016/S0140-6736(21)02143-7

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., van den Hout, M. A., & Baas, J. M. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety*, *32*(4), 239–253. https://doi.org/10.1002/da.22353

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2015). Fear generalization in humans: Systematic review and implications for anxiety disorder research. *Behavior Therapy*, *46*(5), 561–582. https://doi.org/10.1016/j.beth.2014.10.001

Fraunfelter, L., Gerdes, A. B., & Alpers, G. W. (2022). Fear one, fear them all: A systematic review and meta-analysis of fear generalization in pathological anxiety. *Neuroscience & Biobehavioral Reviews*, *139*, Article 104707. https://doi.org/10.1016/j.neubiorev.2022.104707

Gardner, P. J., & Moallef, P. (2015). Psychological impact on SARS survivors: Critical review of the English language literature. *Canadian Psychology/Psychologie Canadienne*, *56*(1), 123–135. https://doi.org/10.1037/a0037973

Gross, C., & Hen, R. (2004). The developmental origins of anxiety. *Nature Reviews Neuroscience*, *5*(7), 545–552. https://doi.org/10.1038/nrn1429

Haddad, A. D., Xu, M., Raeder, S., & Lau, J. Y. (2013). Measuring the role of conditioning and stimulus generalisation in common fears and worries. *Cognition & Emotion*, *27*(5), 914–922. https://doi.org/10.1080/02699931.2012.747428

Hautzinger, H., & Bailer, M. (1993). *Allgemeine Depressionsskala (ADS)*. Beltz.

Hein, G., Gamer, M., Gall, D., Gründahl, M., Domschke, K., Andreatta, M., Wieser, M. J., & Pauli, P. (2021). Social cognitive factors outweigh negative emotionality in predicting COVID-19 related safety behaviors. *Preventive Medicine Reports*, *24*, Article 101559. https://doi.org/10.1016/j.pmedr.2021.101559

Hilbert, K., Boeken, O., Asbrand, J., Seemann, S., Langhammer, T., Praxl, B., Horváth, L., Ertle, A., & Lueken, U. (2022). Who is seeking help for psychological distress associated with the COVID-19 pandemic? Characterization of risk factors in 1269 participants accessing low-threshold psychological help. *PLoS ONE*, *17*(7), Article e0271468. https://doi.org/10.1371/journal.pone.0271468

Hong, X., Currier, G. W., Zhao, X., Jiang, Y., Zhou, W., & Wei, J. (2009). Posttraumatic stress disorder in convalescent severe acute respiratory syndrome patients: A 4-year follow-up study. *General Hospital Psychiatry*, *31*(6), 546–554. https://doi.org/10.1016/j.genhosppsych.2009.06.008

Hunt, C., Webler, R., Emich, A., FhongHiljus, K. J., & Lissek, S. (2022). Pre-COVID-19 fear conditioning responses predict COVID-19-related anxiety: Evidence from an exploratory study. *Anxiety, Stress, and Coping*, *35*(5), 547–576. https://doi.org/10.1080/10615806.2022.2033735

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D. S., Quinn, K., Sanislow, C., & Wang, P. (2010). Research domain criteria (RDoC): Toward a new classification framework for research on mental disorders. *The American Journal of Psychiatry*, *167*(7), 748–751. https://doi.org/10.1176/appi.ajp.2010.09091379

Jeong, H., Yim, H. W., Song, Y. J., Ki, M., Min, J. A., Cho, J., & Chae, J. H. (2016). Mental health status of people isolated due to Middle East Respiratory Syndrome. *Epidemiology and Health*, *38*, Article e2016048. https://doi.org/10.4178/epih.e2016048

Kaczkurkin, A. N., Burton, P. C., Chazin, S. M., Manbeck, A. B., Espensen-Sturges, T., Cooper, S. E., Sponheim, S. R., & Lissek, S. (2017). Neural substrates of overgeneralized conditioned fear in PTSD. *American Journal of Psychiatry*, *174*(2), 125–134. https://doi.org/10.1176/appi.ajp.2016.15121549

Kemper, C. J., Ziegler, M., & Taylor, S. (2009). Überprüfung der psychometrischen Qualität der deutschen Version des Angstsensitivitätsindex-3. *Diagnostica*, *55*(4), 223–233. https://doi.org/10.1026/0012-1924.55.4.223

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Life-time prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*(6), 593–602. https://doi.org/10.1001/archpsyc.62.6.593

Kindt, M. (2014). A behavioural neuroscience perspective on the aetiology and treatment of anxiety disorders. *Behaviour Research and Therapy*, *62*, 24–36. https://doi.org/10.1016/j.brat.2014.08.012

Kwong, A. S. F., Pearson, R. M., Adams, M. J., Northstone, K., Tilling, K., Smith, D., Fawns-Ritchie, C., Bould, H., Warne, N., Zammit, S., Gunnell, D. J., Moran, P. A., Micali, N., Reichenberg, A., Hickman, M., Rai, D., Haworth, S., Campbell, A., Altschul, D., ..., & Timpson, N. J. (2021). Mental health before and during the COVID-19 pandemic in two longitudinal UK population cohorts. *The British Journal of Psychiatry*, *218*(6), 334–343. https://doi.org/10.1192/bjp.2020.242

Lau, J. Y. F., Lissek, S., Nelson, E. E., Lee, Y., Roberson-Nay, R., Poeth, K., Jenness, J., Ernst, M., Grillon, C., & Pine, D. S. (2008). Fear conditioning in adolescents with anxiety disorders: Results from a novel experimental paradigm. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(1), 94–102. https://doi.org/10.1097/chi.0b01e31815a5f01

Laux, L., Glanzmann, P., Schaffner, P., & Spielberger, C. D. (1981). *Das State-Trait-Angstinventar: STAI*. Beltz-Test.

Lissek, S., Kaczkurkin, A. N., Rabin, S., Geraci, M., Pine, D. S., & Grillon, C. (2014). Generalized anxiety disorder is associated with overgeneralization of classically conditioned fear. *Biological Psychiatry*, *75*(11), 909–915. https://doi.org/10.1016/j.biopsych.2013.07.025

Lissek, S., Powers, A. S., McClure, E. B., Phelps, E. A., Woldehawariat, G., Grillon, C., & Pine, D. S. (2005). Classical fear conditioning in the anxiety disorders: A meta-analysis. *Behaviour Research and Therapy*, *43*(11), 1391–1424. https://doi.org/10.1016/j.brat.2004.10.007

Lissek, S., Rabin, S., Heller, R. E., Lukenbaugh, D., Geraci, M., Pine, D. S., & Grillon, C. (2010). Overgeneralization of conditioned fear as a pathogenic marker of panic disorder. *American Journal of Psychiatry*, *167*(1), 47–55. https://doi.org/10.1176/appi.ajp.2009.09030410

Lonsdorf, T. B., Klingelhöfer-Jens, M., Andreatta, M., Beckers, T., Chalkia, A., Gerlicher, A., Jentsch, V. L., Meir Drexler, S., Mertens, G., Richter, J., Sjouwerman, R., Wendt, J., & Merz, C. J. (2019). Navigating the garden of forking paths for data exclusions in fear conditioning research. *eLife*, *8*, Article e52465. https://doi.org/10.7554/eLife.52465

Malesza, M., & Kaczmarek, M. C. (2020). Predictors of anxiety during the COVID-19 pandemic in Poland. *Personality and Individual Differences*, *170*, Article 110419. https://doi.org/10.1016/j.paid.2020.110419

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, *28*(6), 487–495. https://doi.org/10.1016/0005-7967(90)90135-6

Özdin, S., & Bayrak Özdin, Ş. (2020). Levels and predictors of anxiety, depression and health anxiety during COVID-19 pandemic in Turkish society: The importance of gender. *International Journal of Social Psychiatry*, *66*(5), 504–511. https://doi.org/10.1177/0020764020927051

Reutter, M., & Gamer, M. (2022). Individual patterns of visual exploration predict the extent of fear generalization in humans. *Emotion*. Advance online publication. https://doi.org/10.1037/emo0001134

Robinson, E., Sutin, A. R., Daly, M., & Jones, A. (2022). A systematic review and meta-analysis of longitudinal cohort studies comparing mental health before versus during the COVID-19 pandemic in 2020. *Journal of Affective Disorders*, *296*, 567–576. https://doi.org/10.1016/j.jad.2021.09.098

Scheveneels, S., Boddez, Y., & Hermans, D. (2021). Predicting clinical outcomes via human fear conditioning: A narrative review. *Behaviour Research and Therapy*, *142*, Article 103870. https://doi.org/10.1016/j.brat.2021.103870

Schiele, M. A., Reinhard, J., Reif, A., Domschke, K., Romanos, M., Deckert, J., & Pauli, P. (2016). Developmental aspects of fear: Comparing the acquisition and generalization of conditioned fear in children and adults. *Developmental Psychobiology*, *58*(4), 471–481. https://doi.org/10.1002/dev.21393

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59*(Suppl 20), 22–57.

Stegmann, Y., Schiele, M. A., Schümann, D., Lonsdorf, T. B., Zwanzger, P., Romanos, M., Reif, A., Domschke, K., Deckert, J., Gamer, M., & Pauli, P. (2019). Individual differences in human fear generalization—Pattern identification and implications for anxiety disorders. *Translational Psychiatry*, *9*(1), Article 307. https://doi.org/10.1038/s41398-019-0646-8

Struyf, D., Zaman, J., Vervliet, B., & van Diest, I. (2015). Perceptual discrimination in fear generalization: Mechanistic and clinical implications. *Neuroscience & Biobehavioral Reviews*, *59*, 201–207. https://doi.org/10.1016/j.neubiorev.2015.11.004

Tinoco-González, D., Fullana, M. A., Torrents-Rodas, D., Bonillo, A., Vervliet, B., Blasco, M. J., Farré, M., & Torrubia, R. (2015). Conditioned fear acquisition and generalization in generalized anxiety disorder. *Behavior Therapy*, *46*(5), 627–639. https://doi.org/10.1016/j.beth.2014.12.004

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006

Trull, T. J., & Ebner-Priemer, U. (2013). Ambulatory assessment. *Annual Review of Clinical Psychology*, *9*, 151–176. https://doi.org/10.1146/annurev-clinpsy-050212-185510

Yarrington, J., Lasser, J., Garcia, D., Vargas, J., Couto, D., Marafon, T., Craske, M., & Niles, A. (2021). Impact of the COVID-19 Pandemic on mental health among 157,213 Americans. *Journal of Affective Disorders*, *286*, 64–70. https://doi.org/10.1016/j.jad.2021.02.056

Zeidan, M. A., Lebron-Milad, K., Thompson-Hollands, J., Im, J. J., Dougherty, D. D., Holt, D. J., Orr, S. P., & Milad, M. R. (2012). Test–retest reliability during fear acquisition and fear extinction in humans. *CNS Neuroscience & Therapeutics*, *18*(4), 313–317. https://doi.org/10.1111/j.1755-5949.2011.00238.x

History
Received September 26, 2022
Revision received February 7, 2023
Accepted March 12, 2023
Published online May 30, 2023

Acknowledgments
The authors would like to thank Sabrina Graf for her help with participant recruitment and data acquisition for the online questionnaire at T1 and all student assistants who supported data acquisition in the laboratory experiment at T0.

Publication Ethics
Written informed consent was obtained from each participant at each time point. The study was approved by the ethic committees of the involved Universities and was conducted in accordance with the ethical principles of the Helsinki Declaration.

Authorship
The authors Celina Imholze and Katharina Hutterer contributed equally. Celina Imholze, writing – original draft, writing – review & editing; Katharina Hutterer, conceptualization, writing – original draft, writing – review & editing; Dominik Gall, conceptualization, data curation, formal analysis, visualization, writing – review & editing; Udo Dannlowski, funding acquisition, writing – review & editing; Katharina Domschke, funding acquisition, writing – review & editing, Elisabeth J. Leehr, writing – review & editing; Ulrike Lueken, funding acquisition, writing – review & editing; Tina B. Lonsdorf, funding acquisition, writing – review & editing; Andreas Reif, funding acquisition, writing – review & editing; Karoline Rosenkranz, writing – review & editing; Miriam A. Schiele, writing – review & editing; Peter Zwanzger, funding acquisition, writing – review & editing; Paul Pauli, funding acquisition, conceptualization, writing – review & editing; Matthias Gamer, funding acquisition, conceptualization, writing – original draft, writing – review & editing.

Funding
This research was supported by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), Project Number 44541416-TRR58. Open access publication enabled by the University of Würzburg, Germany.

ORCID
Katharina Hutterer
https://orcid.org/0000-0003-1275-5980
Udo Dannlowski
https://orcid.org/0000-0002-0623-3759
Elisabeth J. Leehr
https://orcid.org/0000-0002-9264-5003
Tina B. Lonsdorf
https://orcid.org/0000-0003-1501-4846
Andreas Reif
https://orcid.org/0000-0002-0992-634X
Matthias Gamer
https://orcid.org/0000-0002-9676-9038

Matthias Gamer
Department of Psychology
University of Würzburg
Marcusstr. 9-11
97070 Würzburg
Germany
matthias.gamer@uni-wuerzburg.de