Neuroticism and emotional risk during the COVID-19 pandemic ☆

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ABSTRACT

Large-scale health crises, such as the COVID-19 pandemic, may evoke negative affective responses, which are linked to psychological maladjustment and psychopathology. Here, we shed light on the role of the personality trait neuroticism in predicting who experiences negative affective responses. In a large-scale experience-sampling study (N = 1,609; 38,120 momentary reports), we showed that individuals high in neuroticism experienced more negative affect and higher affective variability in their daily lives. Individuals high in neuroticism also (a) paid more attention to COVID-19-related information and worried more about the consequences of the pandemic (crisis preoccupation), and (b) experienced more negative affect during this preoccupation (affective reactivity). These findings offer new insights into the consequences and dynamics of neuroticism in extreme environmental contexts.

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1. Neuroticism and emotional risk during the COVID-19 pandemic

Large-scale health crises, such as the COVID-19 pandemic, pose serious health threats to members of affected societies. Humans generally respond to such threats with negative affect, which may lead to lower psychological well-being and psychopathology (Brooks et al., 2020; Wichers, 2014). To identify and support individuals with negative affective responses, policymakers and journalists typically emphasize the role of sociodemographic factors (e.g., advanced age, living alone). Previous research has, however, shown that individual differences in personality predict psychological well-being beyond these aspects (Boyce, Wood, & Powdthavee, 2013). The present research aims to evaluate the relationship between personality and negative affect in an extreme environmental context that should strongly trigger individual differences in affective functioning. We focus on neuroticism, a personality trait that has far-reaching public health significance (Lahey, 2009). First, we examine whether neuroticism is associated with negative affect level and variability. Second, we investigate whether neuroticism is related to (a) higher attention to COVID-19-related information and higher engagement in COVID-19-related worries (crisis preoccupation), and (b) stronger negative affect during this preoccupation (affective reactivity).

1.1. Neuroticism and negative affect

Neuroticism refers to individual differences in negative emotionality (Barlow, Sauer-Zavala, Carl, Bullis, & Ellard, 2014; Lahey, 2009) and predicts a range of negative outcomes, including low subjective well-being (Lucas, 2018; Soto, 2019) and poor physical and mental health (Kotov, Gamez, Schmidt, & Watson, 2010; Malouff, Thorsteinsson, & Schutte, 2005). In previous experience-sampling studies that repeatedly asked individuals about their everyday life experiences, individuals with high levels of neuroticism reported more negative affect on average (i.e., higher negative affect levels). In some studies, individuals with high levels of neuroticism also varied more in their in negative affect from moment to moment (Geukes, Nestler, Hutteman, Küfner, & Back, 2017) – although the robustness of these findings is currently a subject of debate (Hisler, DeHart, Krizan, & Wright, 2020; Kalokerinos et al., 2020; Wendt et al., 2020). Please note that variability refers to fluctuations around a general tendency and does not consider temporal dependency (Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009). Thus, these studies examined the association of

neuroticism with the degree to which individuals showed similar levels of negative affect across situations (low variability) versus strong differences in negative affect across situations (high variability), independent of their temporal ordering.

The COVID-19 pandemic represents an extreme situation that poses unique mental health challenges (Galea, Merchant, & Lurie, 2020; Holmes et al., 2020), and it is unclear how the relationships between neuroticism and negative affect level and variability unfold during a pandemic. Some have argued that individual differences in personality should be studied during environmental challenges because novel and uncertain situations are more likely to reveal the effects of dispositional tendencies on people's everyday experiences and behaviors (Caspi & Moffitt, 1993). This argument is backed up by dynamic theories of personality (Denissen & Penke, 2008; Tett & Guterman, 2000), which posit that individual differences in personality should be more consequential in situations that activate the traits. Following this logic, the COVID-19 pandemic, which is marked by stressors such as threat and uncertainty, represents a prototypical situation to study the effects of neuroticism on everyday negative affect. Alternatively, the COVID-19 situation may induce extreme situational pressures that obliterate the relationship between neuroticism and negative affect (Cooper & Withey, 2009). Examining the effects of neuroticism on negative affect level and variability during the COVID-19 pandemic, thus, does not only allow to identify a potentially important but overlooked predictor of negative affect during the crisis, it also allows to test basic principles of personality expression in extreme environmental contexts.

First studies have examined well-being and mental health symptoms during the COVID-19 pandemic (Rajkumar, 2020; Thombs et al., 2020) and identified risk groups based on socio-demographic variables (Lai et al., 2020; Wang et al., 2020). Importantly, these studies captured well-being in decontextualized ways and cannot speak to the effects on negative affect as it is experienced in people's daily lives, fluctuating from moment to moment and embedded into actual situations. The few existing experience-sampling studies that investigated fluctuations in negative affect during the COVID-19 pandemic (e.g., Fried, Papanikolaou, & Epskamp, 2020; Huckins et al., 2020; Stieger, Lewetz, & Swami, 2020) were all comparatively small (*N* = 80, 286, and 217, respectively), mostly focused on specific populations (e.g., college students), and did not examine personality predictors of negative affective states. Based on these gaps in the literature, a first goal of this research is to provide robust empirical evidence to resolve whether and how strongly neuroticism predicts negative affect level and variability in this unprecedented situation.

1.2. Crisis preoccupation and affective reactivity

To better understand the relationship between neuroticism and negative affect during the COVID-19 pandemic, we further zoom in on two processes that have been linked to neuroticism before COVID-19: crisis preoccupation and affective reactivity. First, previous research has shown that individuals high in neuroticism are prone to rumination and worry, which are both crucially involved in mental health problems (Merino, Senra, & Ferreiro, 2016; Muris, Roelofs, Rassin, Franken, & Mayer, 2005). Prior to the pandemic, these worries may have centered around various issues other than COVID-19 (e.g., occupational, interpersonal, or financial problems). Here, we aim to examine whether the worries also attach themselves to pandemic-related content. Specifically, we investigate whether individuals high in neuroticism pay more attention to COVID-19-related information and worry more about the consequences of the pandemic (e.g., for their own health; crisis preoccupation). Because repetitive negative thoughts are linked to

psychological distress (Watkins, 2008), crisis preoccupation may contribute to heightened levels of negative affect.

A second process that has been linked to neuroticism before the COVID-19 pandemic is affective reactivity to stress (Bolger & Schilling, 1991). The neuroticism – stress-reactivity relationship is backed up by daily diary studies, in which individuals high in neuroticism reacted more negatively to stressful events (Hisler, DeHart, Krizan, & Wright, 2020; Howland, Armeli, Feinn, & Tennen, 2017; Suls & Martin, 2005). During the COVID-19 pandemic, attention to COVID-19 related information and health-related worries may act as cognitive stressors that trigger negative affective reactions, particularly in individuals high in neuroticism (i.e., affective reactivity). Stronger affective reactivity may contribute to both heightened levels of negative affect and heightened affective variability. Yet, most previous studies on the neuroticism – stress-reactivity relationship focused on objective daily stressors and only few studies have examined individual differences in affective reactivity in response to cognitive preoccupation (Segerstrom, Gloger, Hardy, & Crofford, 2020). In addition, previous investigations of real-life preoccupation and affective reactivity processes took place outside of an immediate crisis context. A second goal of this research is, thus, to provide a high-powered investigation of crisis preoccupation and affective reactivity processes in a directly relevant context.

1.3. The present study

This study uses cutting-edge experience-sampling methodology (Myin-Germeys et al., 2009; Wright & Zimmermann, 2019) to examine the relationship between neuroticism and (a) negative affect level and variability, and (b) crisis preoccupation and affective reactivity during the early phases of the COVID-19 pandemic in Germany (March 18 – April 3, 2020). The COVID-19 pandemic reached Germany on January 27 when the first person in Bavaria was infected with the virus. The virus quickly spread to other states and on March 8, the first death due to COVID-19 was reported in Germany. On March 11, the World Health Organization declared COVID-19 a global health pandemic (World Health Organization, 2020). In Germany, first nationwide restrictions were announced on March 16, including travel bans, the closure of kindergartens, schools, universities, and many non-essential stores and facilities (e.g., bars, clubs, discos, theatres, museums, concert halls, cinemas, zoos, leisure parks, sports facilities, playgrounds). These restrictions led to severe disruptions of people's everyday lives. Many people were forced to work from home, homeschool their children, and to physically distance themselves from others. On March 18, the day when the data collection started, Chancellor Angela Merkel called COVID-19 Germany's greatest challenge since World War II. The restrictions were further intensified on March 22, when the German government announced a decree of restrained contact to prohibit gatherings of more than two people from different households. In addition, the study period (March 18 – April 3, 2020) was marked by a rapid increase of infections and deaths from 10,999 to 79,696 and 20 to 1,017, respectively (Robert Koch Institute, 2020a, 2020b).

During this period, a large sample of participants (*N* = 1,609) initially completed an online survey on demographic, personality, and individual COVID-19-related information (e.g., personally experienced health threats). They then provided fine-grained, longitudinal measures of their daily activities over the course of 2 weeks. Analyses focused in the relationships between neuroticism and (a) negative affect level and variability, and (b) crisis preoccupation and affective reactivity.

Our study seeks to extend previous work by (a) examining the role of neuroticism during an unprecedented health crisis, (b) capturing both the level and variability in negative affect, and (c)

focusing on crisis preoccupation and affective reactivity processes. It thus allows for robust insights that are needed to (a) derive scientifically informed strategies for dealing with major health crises, and (b) test theoretical principles on the consequences and dynamics of neuroticism in high stakes contexts.

2. Method

In this Method section, we describe the sample and relevant procedures and measures of the data collection project. A codebook with a full description of all procedures and measures applied in this project as well as all data and analytical code necessary to reproduce reported results can be retrieved from https://osf.io/46etw/. All procedures used in this study were approved by the review board of the University of Münster, Germany. None of the tested hypotheses was preregistered.

2.1. Participants

Data for the present paper were provided by a German convenience sample consisting of 1,609 participants (78% women, M_{age} = 33.7 years, SD_{age} = 12.7, Range = 16–83). Most participants (84%) held at least an A-level (German Abitur), and most of them were either working (51%) or attending a university program (37%). Participants were recruited via media announcements and received personalized feedback in May 2020 on their emotional states as an incentive for participation.

2.2. Procedures

The study was programmed in formR version v0.18.3 (Arslan, Walther, & Tata, 2020) and released on March 18, 2020. The study began when social distancing measures were recommended but not yet officially advised (March 18) and covered critical events such as the decree of restrained contact on March 22 and the decree of prolonged restrained contact on April 1, as well as marked increases in deaths due to COVID-19 (from 20 deaths on March 19 to 1,017 deaths on April 3).

Data collection consisted of three phases: an initial and a final online survey and an experience-sampling phase in between. For the initial online survey (Day 1), participants provided informed consent and information on demographic variables (e.g., age, sex, cohabitation status, educational status, occupational status), on personality traits (e.g., neuroticism), and on their experiences during the COVID-19 pandemic (e.g., personally experienced health threats). The subsequent experience-sampling phase (Days 2–15) began the next day in the morning. Participants completed up to six surveys per day for a maximum of 14 days. Each survey assessed momentary states (e.g., negative affect, attention to COVID-19-related information, and engagement in COVID-19-related worries) and took about 2 min to complete. Participants received an email reminder for each survey that provided them with a personalized link to the respective survey. The emails were sent at random time points throughout the day based on individual time preferences for daily start and end times, with the stipulation that two successive surveys had to be a minimum of 40 min apart. Surveys were accessible for 45 min after the email reminder was sent. If participants did not respond to a reminder within 20 min, one additional reminder was sent. The first item of every ESM survey asked participants whether they had engaged in a social interaction (>5 min) since the last survey. If participants answered "yes", all subsequent questions referred to their most recent social interaction. If they answered "no", all subsequent questions referred to their most recent individual activity. An individual activity was defined as the last situation that lasted at least

5 min and during which the participant did not interact with others (see https://osf.io/46etw/ for the original wording of all measures). The link to the final online survey was sent the day after the experience-sampling phase was completed (Day 16). In this online survey, participants provided (additional) information on demographic variables (i.e., relationship status, information about social networks) as well as on personality traits and their experiences during the COVID-19 pandemic.

We aimed to collect as many participants as possible within the critical time period to obtain precise estimates of effect sizes. For the present analyses, we included participants (N = 1,609) with the initial and the experience-sampling surveys who provided state data on or before April 3, 2020. This cut-off date was chosen as most participants had started within the first three days of the study. The number of completed surveys per day decreased strongly after April 3, as fewer participants were still enrolled. Moreover, we included data on the final COVID-19 survey for participants (n = 686) who completed the whole study on or before April 4, 2020, that is, who started within the first three days of the study. Surveys were excluded in cases of partial completion. On average, participants of this study took part for 7.4 days (Mdn = 7) and completed 3.2 surveys (Mdn = 3) per day, with a total average of 23.7 surveys (Mdn = 15) per participant. Note that our final sample includes a high number of participants who completed only one (n = 158), two (n = 115), or three (n = 109) surveys. Because our focus is on dynamic changes within individuals and thus requires repeated measurements, we reran all analyses with a subsample of participants who provided at least 10 assessments (n = 942; total = 35,664 momentary reports).

2.3. Measures

Whenever items were aggregated to form a composite score, we either computed a mean per participant (trait measures) or a mean per time point per participant (state measures).

2.3.1. Sociodemographic information (Trait Survey)

For the sociodemographic variables, we assessed age, sex, educational status, occupational status, and participants' household size. The last variable was recoded into a dummy variable that indicated whether or not participants were living with others or alone (cohabitation status). Moreover, participants indicated whether (*Yes*) or not (*No*) their personal social network included grandparents, parents, siblings, their own children, and a partner.

2.3.2. Neuroticism (Trait Survey)

Participants completed the Neuroticism subscale from the German version of the Big Five Inventory-2 S (Rammstedt, Danner, Soto, & John, 2018). This scale comprises six items, with two items assessing the neuroticism facets anxiety, depression, and emotional volatility, respectively. These items were answered on 5-point rating scales with the anchors: 1 (*disagree strongly*), 2 (*disagree a little*), 3 (*neutral; no opinion*), 4 (*agree a little*), and 5 (*agree strongly*).

2.3.3. Personally experienced health threats (Trait Survey)

To assess the extent to which participants were personally affected by the COVID-19 pandemic, they completed a total of six items. Four were used in the present study because they were deemed theoretically most relevant and exhibited considerable variance between individuals. These items were answered on a dichotomous response format (*Yes* vs. *No*) and targeted different degrees of personal health threat. The items read: "Are you in voluntary quarantine?" "Are you in mandatory quarantine?" "Do you have or did you have the typical disease symptoms (e.g., fever, cough)?" and "Do you think one or more people in your household

are part of the risk group for the Coronavirus?" We formed a composite score reflecting the degree of experienced health threats by summing (a) whether participants were in either voluntary or mandatory quarantine, (b) whether participants had the typical disease symptoms (e.g., fever, cough), and (c) whether participants thought that one or more people in their household belonged to the risk group for COVID-19.

2.3.4. Negative affect (State Survey)

Participants rated their emotional states on a total of 16 items. Three items were included as indicators of negative affect for this study on the basis of their theoretical relevance. Depending on whether or not participants had engaged in a social interaction (>5 min) since the last survey, the item stem read either "How did you feel directly after the interaction?" or "How did you feel directly after the activity?" The items themselves were "anxious," "relaxed" (reverse coded), and "insecure." These items were answered on 6-point rating scales ranging from 1 (*do not agree at all*) to 6 (*agree completely*) and aggregated on the basis of conceptual reasons.

2.3.5. Attention to COVID-19-related information (State Survey)

To assess attention to COVID-19-related information, participants completed different versions of one item, depending on whether or not they had engaged in a social interaction (>5 min) since the last survey. If participants reported a social interaction, the item stem read "During the interaction, I showed the following behavior:" and the item read "I addressed the topic of Coronavirus." When there had been no social interaction, the item stem read "During the activity, I experienced the following:" and the item read "I thought about the Coronavirus." Both items were answered on 6-point rating scales ranging from 1 (*do not agree at all*) to 6 (*agree completely*).

2.3.6. COVID-19-related worries (State Survey)

To assess COVID-19-related worries, participants completed a total of 14 items, all of which had the item stem "Because of the spread of the Coronavirus, I worry about…" and were answered on a rating scale from 1 (*very little*) to 6 (*very much*). Three items targeted worries about oneself. The item wordings were "…my health," "…my social life," and "…my studies/work life." Three items referred to worries about "my parents' health," "…my close friends' health," and "…the health of members of my wider social environment (classmates, other acquaintances)." These items were aggregated to form an index of worries about others' health. Four additional items were aggregated to form an index of worries about societal issues, that is, "…the health system in Germany," "…the social cohesion in Germany," "…the economy/work life in Germany," and "…the cultural life in Germany." Finally, worries about one's own health, one's social life, one's work/studies, others' health, and societal issues were averaged to form an aggregate of different types of worry.

2.4. Analytical strategy

For the statistical analyses, all continuous variables were *z*-standardized across the entire dataset. Sex, cohabitation status, the presence versus absence of social interactions, and weekend versus weekday were dummy-coded. Educational status and occupational status were treated as categorical variables. All analyses were run in *R* (R Core Team, 2018) or *Mplus* 8 (Muthén & Muthén, 2017).

In a first step, we investigated the between-person correlations of all main variables included in our analyses, using the R-package *psych* (Revelle, 2018). Next, we ran multilevel models with the R-package *nlme* (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team,

2020), in which neuroticism predicted participants' random intercepts in negative affect. We used three-level models with measurement occasions nested in days and days nested in participants and included a residual autocorrelation for consecutive measurement occasions within the same day. Moreover, we controlled for several between-person (age, sex, cohabitation status, educational status, occupational status, personally experienced health threats) and time-varying variables (presence vs. absence of social interactions, weekend vs. weekday, time).

To examine the relationships between neuroticism and variability in negative affect, we ran multilevel location scale models. These models represent an extension of standard multilevel models, in which the residual terms are allowed to vary between individuals (Geukes, Nestler, Hutteman, Küfner, & Back, 2017). Both random intercepts (representing mean levels) and random residual variances (representing within-person variability) were modelled as latent variables, which were allowed to covary. In the first model, neuroticism was used as a between-person predictor of the random intercepts and residual variances. The results reflect the correlations between neuroticism and negative affect level und variability, respectively. In the second model, the random intercepts and residual variances were regressed onto neuroticism simultaneously to examine their unique associations with neuroticism. The results can be interpreted as the semi-partial or part correlations between neuroticism and negative affect level und variability, respectively (Hisler, DeHart, Krizan, & Wright, 2020). All models were estimated in *Mplus* using the default, uninformed priors. The parameter estimates were based on two chains with 5000 iterations each (2500 iterations were discarded as burn-in). Variability was modelled as the log-transformed residual variance to preclude negative values. The *Mplus* code was adapted from McNeish (2020) and can be retrieved from our OSF page (https://osf.io/46etw/).

In a second step, we examined the associations between negative affect, attention to COVID-19, and worries about one's own health, with a particular focus on whether neuroticism moderated these associations (affective reactivity). To this end, we specified similar multilevel models as described above (i.e., three levels, autocorrelated residuals). Whenever worries or attention to COVID-19 served as an independent variable, they were disaggregated into their within-person (WP) and between-person (BP) parts. To this end, we included two predictors in our models: the person mean (BP predictor) and the time-specific deviation from the person mean (WP predictor). The within-person effects were allowed to vary between participants. Affective reactivity was assessed as the cross-level interaction between neuroticism and attention to COVID-19 and between neuroticism and worries about one's own health in the prediction of negative affect, respectively. Moreover, the interaction between neuroticism and attention to COVID-19 in the prediction of worries about one's own health was examined. In all three models, we examined whether neuroticism was related to both the within- and between-person effect. These analyses were repeated by simultaneously including the between-person and time-varying control variables described above. Due to the high number of statistical tests, we used an alpha level of 0.01 (two-sided) for all tests and report 99%-confidence intervals.

We conducted four sets of robustness analyses. First, we examined whether our results regarding worries about one's own health generalized to a broad worry aggregate including five worry variables. Second, we investigated whether our findings were robust to log-transforming negative affect, because the distribution of negative affect is often skewed. Third, we repeated the affective reactivity analyses with the other Big Five traits (extraversion, agreeableness, conscientiousness, openness) and with the three neuroticism facets anxiety, depression, and emotional volatility. Finally, the correlational analyses, variability and affective reactivity analyses were repeated based on a subsample including only

those participants who provided at least 10 valid momentary reports.

To gauge our statistical power to detect our effects of interest, a simulation-based power analysis was carried out. To this end, we focused on two models: (1) the model predicting negative affect from worries about one's own health, neuroticism, and their interaction, and (2) the model predicting negative affect from attention to COVID-19, neuroticism, and their interaction (see Table 3). Our simulation yielded power estimates for effect sizes of varying magnitudes and generally indicated that power was good even for the detection of relatively small effects (i.e., $B = 0.05$). For full details, see Tables S1 and S2 in the Supplementary Materials.

3. Results

Table 1 shows descriptive information for the main variables, including intraclass correlations and reliabilities.

3.1. Neuroticism and negative affect

First, we analyzed whether neuroticism predicted negative affect level and variability during the COVID-19 pandemic in Germany. In line with our hypotheses, neuroticism was associated with higher mean levels of negative affect in daily life, r (1607) = 0.51 [0.46, 0.56], $p < .001$ (see Fig. 1 and Supplementary Table S3). Neuroticism predicted negative affect levels beyond a wide range of control variables. These included person-level variables, such as demographic information (age, sex, cohabitation status, educational status, occupational status) and personally experienced health threats (being in quarantine, having symptoms, living with a person from a risk group), as well as time-varying predictors, namely, the presence versus absence of social interactions, whether it was a weekend versus weekday, and the linear effect of time (Supplementary Table S4). Notably, neuroticism predicted individual differences in negative affect better than all the control variables combined (neuroticism: $R^2 = 0.26$ vs. control variables: $R^2 = 0.03$; Supplementary Table S5).

In multilevel location scale models, neuroticism was not only related to individual differences in mean levels of negative affect, but also to individual differences in within-person variability. Individuals with high levels of neuroticism experienced more negative affect overall ($b = 0.380$ [0.344, 0.415], $p < .001$) and also varied more in their negative affective experiences ($b = 0.284$ [0.245, 0.322], $p < .001$; Table 2). The relationship between neuroticism and affective variability was robust to alternative modeling strate-

gies such as controlling for mean levels (Hisler, DeHart, Krizan, & Wright, 2020), suggesting that neuroticism was uniquely related to both affective characteristics (see Table 2). These findings highlight neuroticism's importance as a predictor of negative affect during major health crises.

The longitudinal course of negative affect is illustrated in Fig. 2. For the entire 2-week period, levels of negative affect were low to moderate for the average person, even lower for individuals low in neuroticism, but considerably elevated for individuals high in neuroticism.

3.2. Crisis preoccupation and affective reactivity

Second, we examined neuroticism's associations with mean levels of attention and worries (crisis preoccupation). As shown in Fig. 1 and Supplementary Table S3, neuroticism was related to paying more attention to COVID-19-related information, r (1607) = 0.18 [0.12, 0.25], $p < .001$, and worrying more about one's own health, $r(1607) = 0.22$ [0.16, 0.28], $p < .001$. We focused on worrying about one's own health because such worries are most clearly conceptually linked to intrapersonal neuroticism processes and the salience of health issues during pandemics. However, the effects were similar for other COVID-19-related worries (see Fig. 1 and Supplementary Table S3).

As depicted in Fig. 2, attention was highest in the beginning of the 2-week period and decreased thereafter. Worries about one's own health increased between March 20 and March 22 (decree of restrained contact) and remained at a high level for the rest of the study. Individuals high in neuroticism consistently paid more attention to COVID-19-related information and worried more about its consequences for their own health.

Finally, we investigated whether neuroticism moderated how strongly attention and worries were related to negative affect (affective reactivity). In multilevel models (see Table 3), both attention to COVID-19-related information and worries about one's own health were related to more negative affect in daily life on the within-person ($b = 0.187$ [0.166, 0.207], $p < .001$ and $b = 0.221$ [0.163, 0.279], $p < .001$, respectively) and between-person level ($b = 0.339$ [0.281, 0.397], $p < .001$ and $b = 0.156$ [0.114, 0.198], $p < .001$, respectively). Attention and worries were mutually related on the within-person ($b = 0.019$ [0.012, 0.026], $p < .001$) and the between-person level ($b = 0.185$ [0.101, 0.270], $p < .001$). In line with the idea of affective reactivity, neuroticism moderated the within-person relationships between attention to COVID-19-related information and negative affect ($b = 0.037$

Table 1
Descriptive Statistics.

Variable	M	SD	ICC1	ICC2	ω_{BP}	ω_{WP}
Level 1						
Negative Affect	2.04	0.96	0.41	0.94	0.78	0.66
Attention to COVID-19	2.32	1.75	0.21	0.87		
Worry About Own Health	3.05	1.70	0.90	>0.99		
Worry About Own Social Life	3.39	1.63	0.85	0.99		
Worry About Own Work/Studies	3.36	1.80	0.88	0.99		
Worry About Others' Health	3.51	1.36	0.92	>0.99	0.87	0.66
Worry About Society	4.27	1.13	0.88	0.99	0.81	0.64
Level 2						
Neuroticism	2.72	0.76			0.82	
Extraversion	3.31	0.67			0.74	
Agreeableness	3.87	0.55			0.70	
Conscientiousness	3.71	0.65			0.76	
Openness	3.64	0.69			0.72	

Note. Shown are descriptive statistics and reliabilities of the examined variables. M = mean; SD = standard deviation; ICC1 = proportion of variance in level-1 variables attributable to between-person variance; ICC2 = precision of the person mean of level-1 variables; ω_{BP} = McDonald's omega total between persons; ω_{WP} = McDonald's omega total within persons. McDonald's omega could not be calculated for one item measures (attention to COVID-19, worry about own health, worry about own social life, worry about own work/studies).
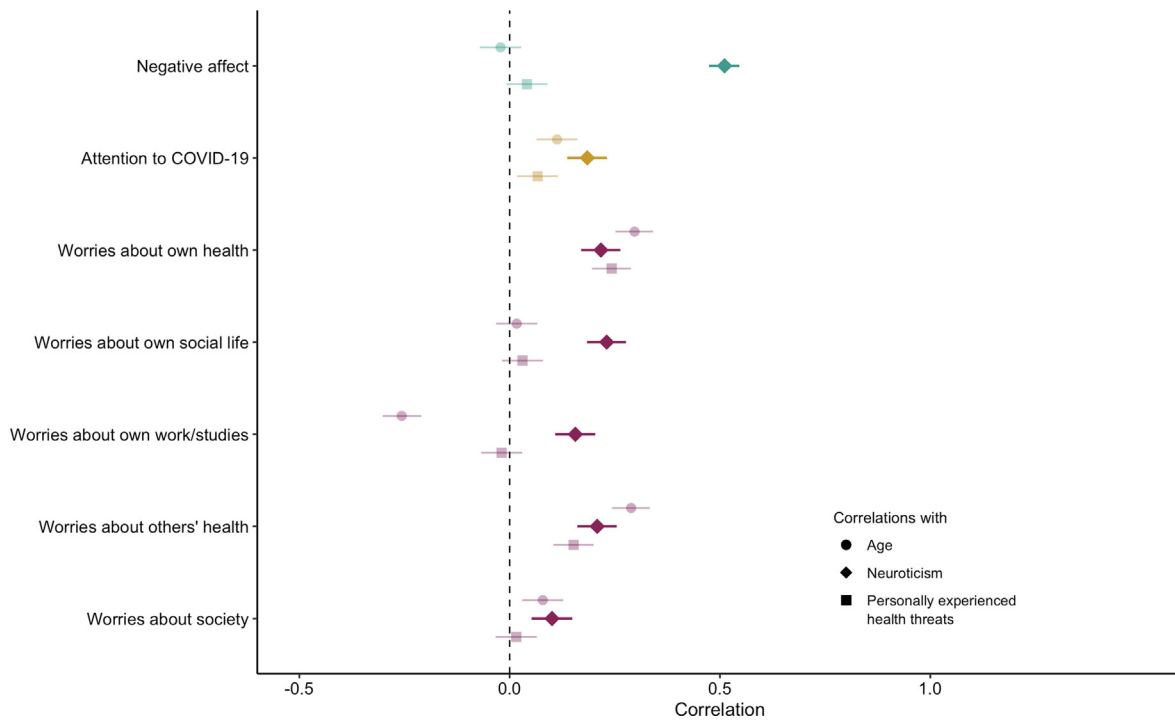
Fig. 1. Illustration of Main Effects of Neuroticism. *Note.* Relationships of neuroticism, age, and personally experienced health threats with negative affect, attention to COVID-19, and worries. Each correlation is shown as a point estimate and 95%-confidence interval.

Table 2
Neuroticism and Negative Affect Mean Levels and Variability.

	Estimate	Post. SD	p
Model 1: Neuroticism Predicting Affective Characteristics			
Neuroticism → Mean Level	0.380	0.018	0.000
Neuroticism → Variability	0.284	0.020	0.000
Mean Level ↔ Variability	0.581	0.021	0.000
Model 2: Regressing Neuroticism on Multiple Affective Characteristics Simultaneously			
Mean Level → Neuroticism	0.431	0.034	0.000
Variability → Neuroticism	0.091	0.037	0.008
Mean Level ↔ Variability	0.655	0.018	0.000

Note. Shown are standardized estimates from multilevel location scale models. All models were estimated using Bayesian estimation procedures with uninformed priors. Variability was modelled as the log-transformed residual variance. Post. *SD* = posterior standard deviation. *P*-values are one-sided.

[0.016, 0.057], *p* < .001) and between worries about one's own health and negative affect (*b* = 0.072 [0.014, 0.129], *p* = .001) but not between attention and worries (*b* = 0.000 [−0.007, 0.007], *p* = .986). In addition, neuroticism moderated the between-person relationship of attention to COVID-19 and negative affect (*b* = 0.116 [0.061, 0.172], *p* < .001).

The effects of neuroticism were substantial in size: An examination of the beta coefficients suggested that the within-person effects of attention and worry on negative affect were approximately 50% (attention) and 95% (worry) higher for those scoring 1 standard deviation above the mean in neuroticism compared with those scoring 1 standard deviation below the mean. The results remained significant when controlling for demographic variables, personally experienced health threats, the presence versus absence of social interactions, weekend versus weekday, and time (Supplementary Table S6). Moreover, the results were similar when examining an aggregate of different types of worry (Supplementary Table S7) and when log-transforming negative affect (Supplementary Table S8).

As part of our sensitivity analyses, we examined the effects of the other Big Five traits (see Supplementary Tables S9–S14) and the effects of the three neuroticism facets anxiety, depression, and emotional volatility separately. The facet findings were similar to the findings for the full trait measure (see Supplementary Tables S15–S18). Lastly, we reran the main analyses for the most compliant participants (at least 10 assessments; *n* = 942; total = 35,664 momentary reports). As shown in Supplementary Tables S19–S21, the results did not change substantially. Our main findings are visually represented in Fig. 3.

4. Discussion

This study shows that global pandemics threaten not only people's physical well-being but also their psychological well-being, particularly for individuals high in neuroticism. In line with findings from representative samples (Entringer & Kröger, 2020), we observed no dramatic increases in negative affect on average. However, there were substantial differences between individuals, and these differences were closely related to neuroticism. Whereas negative affect was low to moderate for most people, people high in neuroticism experienced elevated levels of negative affect throughout the entire study period. The relationship between neuroticism and negative affect was higher than that of socio-demographic variables and personally experienced health threats combined, underlining neuroticism's public health significance (Lahey, 2009). Contrary to previous studies (Hisler, DeHart, Krizan, & Wright, 2020), neuroticism was also uniquely related to higher affective variability. This suggests that during an immediate crisis situation, individuals high in neuroticism experience more negative affect on average and vary more in their negative affect.

In a second step, we identified crisis preoccupation and affective reactivity as two central neuroticism processes in crises situations: Individuals high in neuroticism attend to and worry more about COVID-19-related information (crisis preoccupation) and both attention and worry are linked to more negative affect

Table 3
Neuroticism and Affective Reactivity.

Predictor	Estimate	Std. Error	t	p
Model 1: Worry About Own Health Predicting Negative Affect				
Neuroticism	0.282	0.015	18.265	0.000
Worry About Own Health WP	0.221	0.023	9.795	0.000
Worry About Own Health BP	0.156	0.016	9.534	0.000
Neuroticism * Worry About Own Health WP	0.072	0.022	3.220	0.001
Neuroticism * Worry About Own Health BP	0.026	0.015	1.722	0.085
Model 2: Attention to COVID-19 Predicting Negative Affect				
Neuroticism	0.269	0.015	18.045	0.000
Attention to COVID-19 WP	0.187	0.008	23.445	0.000
Attention to COVID-19 BP	0.339	0.023	15.029	0.000
Neuroticism * Attention to COVID-19 WP	0.037	0.008	4.646	0.000
Neuroticism * Attention to COVID-19 BP	0.116	0.021	5.400	0.000
Model 3: Attention to COVID-19 Predicting Worry About Own Health				
Neuroticism	0.175	0.024	7.268	0.000
Attention to COVID-19 WP	0.019	0.003	6.933	0.000
Attention to COVID-19 BP	0.185	0.033	5.659	0.000
Neuroticism * Attention to COVID-19 WP	−0.000	0.003	−0.018	0.986
Neuroticism * Attention to COVID-19 BP	0.007	0.031	0.241	0.810

Note. The results are based on multilevel models (3 levels: time points nested in days nested in persons) with autoregressive errors and random slopes. All variables were *z*-standardized. Models including control variables can be found in the Supplementary Materials online. WP = within-person; BP = between-person.
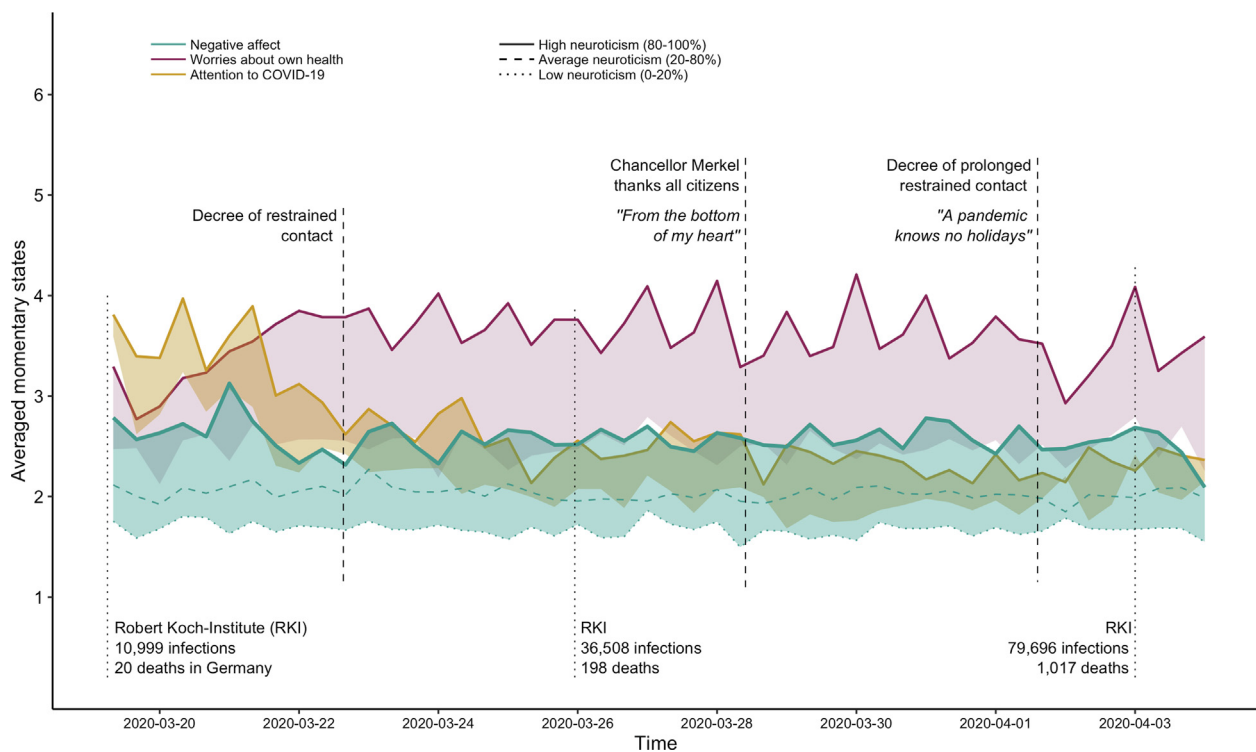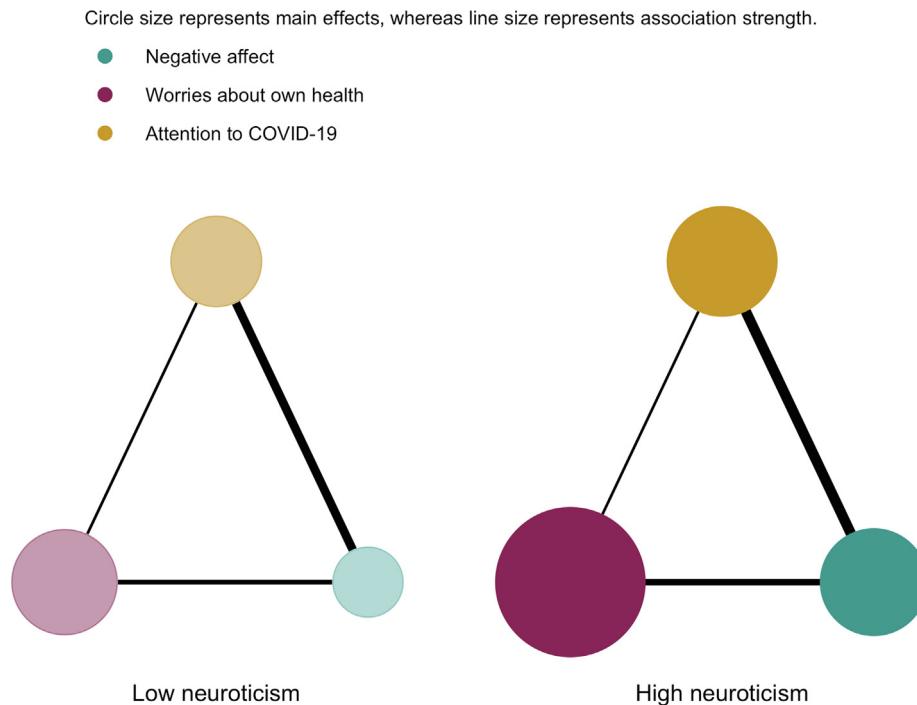

Fig. 2. *Illustration of Longitudinal Effects of Neuroticism. Note.* Longitudinal course of negative affect, attention to COVID-19, and worries over the 2-week period for individuals with high, medium, and low levels of neuroticism. The lower bound of the shaded areas is the typical trajectory for an individual low in neuroticism (percentile 20) and the upper bound is the typical trajectory for an individual high in neuroticism (percentile 80). All items were answered on 6-point rating scales ranging from 1 (*do not agree at all*) to 6 (*agree completely*).

(affective reactivity). These processes may be mutually reinforcing, such that attention to COVID-19 is linked to more worries and negative affect, which in turn are related to more attention. Our findings on neuroticism processes both complement and extend past investigations in several ways. First, our results are in line with pre-pandemic findings on the relationship of neuroticism with rumination and worry (Merino, Senra, & Ferreiro, 2016; Muris, Roelofs, Rassin, Franken, & Mayer, 2005). We extend previous studies by showing that, during COVID-19, negative repetitive thoughts in individuals high in neuroticism are likely to center around COVID-19-related issues. Second, our results dovetail with existing

work on neuroticism and stress reactivity, which has shown that people high in neuroticism react more strongly to daily stressful events (Hisler, DeHart, Krizan, & Wright, 2020; Howland, Armeli, Feinn, & Tennen, 2017; Suls & Martin, 2005), including internal, cognitive stressors such as worries (Segerstrom, Gloger, Hardy, & Crofford, 2020). The present study showed that individuals high in neuroticism also react more negatively to internal, cognitive stressors triggered by major health crises.

Our study was unique because we tested theoretical principles on the consequences and dynamics of neuroticism during an immediate crisis situation. Thus, besides replicating previous find-

Circle size represents main effects, whereas line size represents association strength.

● Negative affect

● Worries about own health

● Attention to COVID-19

Low neuroticism   High neuroticism

Fig. 3. *Illustration of Moderating Effects of Neuroticism. Note.* Networks showing the relationships between attention to COVID-19, worries, and negative affect. High = percentile: 80–100; low = percentile: 0–20.

ings in a well-powered and intensive study, we showed that findings from previous research also apply to extreme environmental contexts. The fact that neuroticism was uniquely linked to higher variability suggests that neuroticism processes may even be enhanced during times of crises. However, based on the present data, we cannot identify whether the relationships between attention and worries with negative affect were accentuated compared to pre-COVID-19 times because we did not have a pre-pandemic baseline. Future studies should compare the relationships between neuroticism, attention, worries, and negative affect before vs. during COVID-19 to delineate which aspects of neuroticism processes have changed as a response to the pandemic.

It is important to note that our investigation provided a rather conservative test of these hypotheses as this study took place in Germany, a country that was only mildly affected by the COVID-19 pandemic during the study period. Therefore, our study may have underestimated the absolute levels of negative affectivity, the effects of neuroticism, and the strength of the underlying processes. It will be important to replicate our findings in other countries that are more seriously affected by the pandemic. Moreover, as our investigation took place during the first weeks of the outbreak, the focus was on short-term stressors and their immediate consequences. Future studies should examine whether the effects reported here weaken or accumulate over time and whether crisis preoccupation and affective reactivity are related to long-term mental health consequences. Lastly, our sample covered a wide age range (16–83) and was thus relatively diverse compared to student samples. Nevertheless, we would like to highlight that participants selected themselves into the sample, which may have led to a selection bias (Schaurer & Weiß, 2020).

Our findings have important implications for applied settings. Identifying groups who experience negative affectivity on the basis of sociodemographic information alone may overlook people in need of help, such as individuals high in neuroticism. Neuroticism is typically assessed via short self-report scales (Rammstedt, Danner, Soto, & John, 2018) but new technologies even allow for the assessment of neuroticism on the basis of digital footprints

(e.g., likes on social media platforms). These technologies could be used to screen large numbers of individuals with minimal effort and to deliver personality-tailored prevention campaigns (e.g., targeting individuals high in neuroticism with information on crisis preoccupation and affective reactivity processes; Matz, Kosinski, Nave, & Stillwell, 2017). Delivering personality-tailored prevention strategies, while considering ethical standards regarding data privacy (Matz, Appel, & Kosinski, 2020), may help to prevent increases in mental health problems due to the COVID-19 and future pandemics (Galea, Merchant, & Lurie, 2020). To implement significant and scientifically informed prevention campaigns, policymakers should actively seek out psychological policy consultation, and psychological scientists should explicitly and responsibly communicate their findings to the public (Bleidorn et al., 2019).

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrp.2020.104038.

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