



Acute stress responses after indirect exposure to the MH17 airplane crash

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People can experience disasters vicariously (indirectly) via conversation, social media, radio, and television, even when not directly involved in a disaster. This study examined whether vicarious exposure to the MH17-airplane crash in Ukraine, with 196 Dutch victims, elicited affective and somatic responses in Dutch adults about 2,600 km away, who happened to participate in an ongoing diary study. Participants ($n = 141$) filled out a diary three times a day for 30 days on their smartphones. Within-person changes in positive affect (PA) and negative affect (NA) and somatic symptoms after the crash were studied. Additionally, we tested whether between-person differences in response could be explained by age, baseline personality (NEO-FFI-3), and media exposure. The MH17 crash elicited a small within-person decrease in PA and an increase in NA and somatic symptoms. This response waned after 3 days and returned to baseline at day four. The decrease in PA was larger in more extraverted participants but smaller in those higher on neuroticism or conscientiousness. The NA response was smaller in elderly. Personality did not seem to moderate the NA and somatic response, and neither did media exposure. Dutch participants showed small acute somatic and affective responses up till 3 days to a disaster that they had not directly witnessed. Vicariously experienced disasters can thus elicit affective-visceral responses indicative of acute stress reactions. Personality and age explained some of the individual differences in this reaction.

The demise of almost 200 of my compatriots has left a hole in the heart of the Dutch nation, has caused grief, anger and despair. Grief for the loss of the loved ones, anger for the outrage of the downing of a civilian airplane and despair after witnessing the excruciatingly slow process of securing the crash site and recovering the remains of the victims.

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Frans Timmermans, Dutch minister of foreign affairs, speech for the United Nations, 22 July 2014.

Humans are hardwired to detect signals of danger, unpredictability, and novelty (Neuberg, Kenrick, & Schaller, 2010; Shackman *et al.*, 2016). People are typically sensitive both to directly or first-hand experienced dangers and to vicarious or indirect exposure via secondary media, including newspapers, radio, television, and social media (Heir, Blix, & Knatten, 2016; Wayment, 2004). Our sensitivity to vicarious events is manifested in the intense emotions people can experience during movies, digital contacts, pornography, and news from around the world (Buss, 2012; Miller & Kanazawa, 2008; Turkle, 2011). As most people spend over five daily hours on secondary media in our globally interconnected modern society (Cloin *et al.*, 2013), disasters may also impact on people geographically far away.

Vicarious exposure to disasters elicits stronger responses when we feel psychologically connected to the victims ('it could have been me', see Dixon, Rehling, & Shiwach, 1993; Wayment, 2004), and when we learn more about the people involved in the disaster, which is known as the 'transportation theory' (Green *et al.*, 2008). Because narrative transportation and perspective taking enable us to know and feel the world of others, mass media tend to focus on drama and individual stories. For example, terrorist attacks are successful in spreading fear among vicariously exposed populations by maximizing media exposure on their terrifying spectacles, their unexpected timing, and the direct victims of the attack (Bleich, Gelkopf, & Solomon, 2003; Galea & Resnick, 2005). Empathy, identification, and narrative transportation can explain why some people respond emotionally to such disasters both geographically nearby and far away, even if there is no harm to close others (Dixon *et al.*, 1993; Heir *et al.*, 2016; Knudsen, Roman, Johnson, & Ducharme, 2005; Wayment, 2004).

Vicarious disaster experiences and mental health

Most studies of disasters and stressors focused on direct victims, but evidence amasses that *vicarious* exposure can also elicit adverse mental and somatic health responses that sometimes may persist for years (Bleich *et al.*, 2003; Dew & Bromet, 1993; Galea & Resnick, 2005; Neria, Nandi, & Galea, 2008; North & Pfefferbaum, 2013; Schuster *et al.*, 2001; van den Berg, Grievink, Yzermans, & Lebet, 2005; World Health Organization, 1995). Famous examples are the stress, anxiety, and somatic complaints after vicarious exposure to the Chernobyl nuclear incident (in 1986; World Health Organization, 1995), the 9/11 terrorist attack on New York and the Pentagon (Ahern, Galea, Resnick, & Vlahov, 2004; Knudsen *et al.*, 2005; Wayment, 2004), and the 2014 Ebola epidemic (Kim, Sherman, & Updegraff, 2016). Moreover, the Three Mile Island nuclear incident in the United States (1979) elicited public adverse mental and somatic health responses without any injury, death, or property damage (Dew & Bromet, 1993), which illustrates the potential role of shared imagination and social amplification of risk (Kasperson *et al.*, 1988). Indications for more long-term vicarious exposure effects were provided by national surveys in the United States, reporting population-level increases in depression and post-traumatic stress disorder (PTSD) symptoms during the first weeks and months after 9/11 (Knudsen *et al.*, 2005; Silver, Holman, McIntosh, Poulin, & Gil-Rivas, 2002). One year after the attacks, roughly 20% of the participants in multiple US population studies reported 9/11 as their worst life event *ever*, despite that none of these participants were present at the attacks, or even knew anyone who died that day (Keyes *et al.*, 2014;

Thompson, Silver, & Holman, 2015). Finally, the Swedish grieved collectively in 1987 after their Prime Minister Olof Palme was murdered (Catalano & Hartig, 2001), whereas the untimely death of Princess Diana of Wales in 1997 elicited global grief responses (Pillow & McNaughton Cassill, 2001).

Reviews by Kasperson *et al.* (1988), Rubonis and Bickman (1991), and Neria *et al.* (2008) indicate that population-level responses typically followed vicarious exposure to (1) the untimely death of a person with a special institutional or societal roles, such as presidents, prime ministers, princesses, and politicians, and (2) major negative expectancy violations, especially technical failure of trusted institutions to perform their essential tasks and to provide safety, including airplane crashes (e.g., Carlier & Gersons, 1997; Smits, Krabbendam, de Bie, Essed, & van Os, 2006), terrorist attacks (e.g., Gruebner *et al.*, 2016; Heir *et al.*, 2016; Holman, Garfin, & Silver, 2014; Rimé, Páez, Basabe, & Martínez, 2010), and nuclear explosions (e.g., Goto, Bromet, & Fujimori, 2015; Samet & Chanson, 2015). Collective responses enable people to derive shared recollections and to weave together a narrative about the world, renewed via annual commemorations, which help us to structure and organize our biographies and to periodate and order time (Brown *et al.*, 2009; Catalano & Hartig, 2001; Kasperson *et al.*, 1988; van den Brink, 2015). Shared narratives also influence subsequent experiences (Rohner & Frey, 2007), as the Fukushima nuclear disaster reminded us of Chernobyl and Ebola of the Spanish flu (Harari, 2015).

The random nature of disaster occurrences has prevented most previous studies to employ optimal research designs, including sufficient repeated assessments within persons (Cohn, Mehl, & Pennebaker, 2004; North & Pfefferbaum, 2013). Most studies included assessments of mental health days, weeks, or months before the disaster and an assessment weeks or months after the disaster, or compared different groups (see for reviews Bromet & Dew, 1995; Neria *et al.*, 2008; Rubonis & Bickman, 1991). The chance that a change in mental health is caused by third factors or merely the passing of time cannot be excluded. A study in which mood just before, during, and after the disaster is monitored would enable to detect in more detail whether within-person shifts in emotional and somatic responses occur from before to after the disaster. Such individual-level processes are unlikely to be revealed in group-level data (Fisher, Megdalia, & Jeronimus, 2018). Moreover, it enables researchers to study how long affective and somatic responses tend to prevail.

The crowdsourcing diary study 'HowNutsAreTheDutch' allows for such an investigation because a disaster happened during the study period: the crash of the MH17 flight (see below). This paper presents a serendipitous study of 141 adults from the general Dutch population who were vicariously exposed to the MH17 crash during an ongoing diary study in which they self-assessed emotions and somatic symptoms three times a day during 30 days (90 assessments). These time series enabled us to track the unfolding response after the MH17 crash in participants who served as their own controls. Specifically, the present study aimed to examine the affective and somatic responses to the MH17 crash. Our expectations were that the MH17 crash was followed by a drop in positive affect (PA) and a rise in negative affect (NA) and somatic symptoms (hypothesis 1 or H1).

The MH17 crash

The Malaysia Airlines Boeing 777 flight MH17 from Amsterdam to Kuala Lumpur was shot down by Russian separatists on 17 July 2014 and crashed near Torez in Ukraine. All 298

passengers died, among which 196 Dutch inhabitants. The MH17 crash was a severe event for the Netherlands because the crash was a directed (terroristic) act of war that unwantedly involved the Netherlands in an international conflict (van den Brink, 2015). The turmoil that was elicited in the Dutch population was evidenced by a peak in indicators of unrest in social media (see Figure 1). The initial reaction to the event became mixed with outrage over the appalling treatment of the victims and looting on the crash site (see top quote). The Dutch held a day of national grief on 23 July, for the first time since the assassination of John F. Kennedy in November 1963, followed by multiple collective commemorations of the MH17 casualties throughout the year (<http://www.government.nl/search?keyword=MH17>). The nationwide scope of the media response to the MH17 crash makes the MH17 crash a 'natural experiment' to study the intensity and persistence of affective and somatic responses in a vicariously exposed population.

Only a few studies aimed to reveal the possible mental health effects of the MH17 crash. Truijens *et al.* (2015) reported increases in depressive symptoms during the first month after the MH17 crash in 126 vicariously exposed pregnant women (at 32-week gestation, $d = 0.30$) compared to 102 controls with similar characteristics during the same summer period 1 year before the crash. These between-group differences in

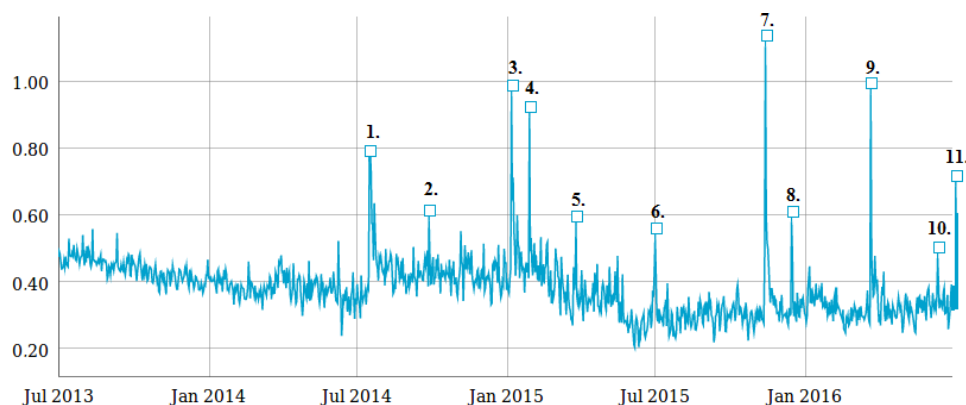


Figure 1. Social tension in the Netherlands as indicated by social media. [Colour figure can be viewed at wileyonlinelibrary.com]

Notes. On the y-axis, we see the percentage of social media messages that include words indicative of social tension (from 0% to 2%) according to Center for Big Data Statistics (2017) Social Tension Indicator (<https://www.cbs.nl/en-gb/our-services/innovation/project/social-tension-indicator-based-on-social-media>). This indicator measures tensions or unrest within Dutch society based on a validated glossary containing words that are specifically related to (un)safety, rather than more general measurements of positive or negative sentiments. Chronologically, we see in this graph: [1] The MH17 crash on 17 July 2014; [2] Monster truck accident on 28 September 2014; [3] Charlie Hebdo attacks in Paris on 7 January 2015; [4] Intruder with a gun at the Dutch national broadcasting foundation, 29 January 2015; [5] Big power outage in the Netherlands, 27 March 2015; [6] Riots in the Schilderswijk The Hague, 2 July 2015; [7] Attacks in Paris, 14 November 2015; [8] National uproar about protest against setting up an asylum centre, 16 December 2015; [9] Attacks in Brussels, 22 March 2016; [10] Shooting in Orlando, 12 June 2016; [11] Attack with truck in Nice, 15 July 2016. The results show that the MH17 disaster (1) was associated with a peak in messages including words indicative of social tension, although the peak was not as high as the peak of the subsequent terrorist attacks in Paris (events 3 and 7) and Brussels (event 9).

depression were replicated by van Gelder, Vlenterie, and Roeleveld (2016), who compared the pregnant women they assessed within 1 month after the MH17 crash ($n = 235$ in their first 17 weeks of pregnancy) versus women in the same stage assessed during the same month 1 or 2 years earlier ($n = 231$). The absence of group differences after gestational week 17 and 34 suggests that this depressed response disappeared within 2 months, which is typical for stressful event effects (Jeronimus, Ormel, Aleman, Penninx, & Riese, 2013; Jeronimus, Riese, Sanderman, & Ormel, 2014). Both studies used suboptimal designs, as they assessed mood in the control groups 1 or 2 years earlier (for potential confounding, see Lakens, 2015), and did not study within-person effects over time but compared two samples, and used pregnant women, who have an increased sensitivity to stressful events (Neria *et al.*, 2008).

Personality differences and vicarious exposure effects

Although we expected vicariously exposed individuals to show affective and somatic responses to the MH17 crash, the intensity of these responses might differ between individuals. People with certain personality traits may be more sensitive to stressful events than others (e.g., Jacobs *et al.*, 2011; Komulainen *et al.*, 2014). Personality is typically defined as the consistent individual differences in what we feel, think, want, and do over time and across context which are commonly organized in five broad trait factors (John, Robins, & Pervin, 2008): extraversion, agreeableness, neuroticism, openness to experience, and conscientiousness. Our expectations were that changes in affect and somatic symptoms after vicarious exposure to the MH17 crash differed along the extraversion, neuroticism, and conscientiousness axes, as outlined below.

The extraversion dimension (positive affectivity/surgency) runs from introversion to extraversion, which is characterized by extraverted sociability, reward sensitivity, more persistent PA, and less NA (Schimmack, 2003; Steel, Schmidt, & Shultz, 2008). After direct stress exposure, introversion predicted the development of more depressive (Kopala-Sibley *et al.*, 2016) and PTSD symptoms (Ogle, Siegler, Beckham, & Rubin, 2016; Stevanovic, Franciskovic, & Vermetten, 2016). This suggests that extraversion can buffer against NA and somatic symptoms. We therefore expected stronger affective and somatic responses in more introverted people (H2a; Hemenover, 2003; Schimmack & Diener, 1997; Schimmack, 2003; Williams, 1989).

The neuroticism dimension (negative affectivity) runs from emotional stability, characterized by being calm and relaxed, to high neuroticism, characterized by a propensity to experience stress, to perceive contextual threat (Ormel *et al.*, 2013; Shackman *et al.*, 2016), and to experience frequent, intense, and persistent NA but less PA (Schimmack, 2003; Steel *et al.*, 2008). After direct exposure to threat, high neuroticism predicts more NA, acute fear, and distress (Connor-Smith & Flachsbart, 2007; Hengartner, van der Linden, Bohleber, & von Wyl, 2016) as well as the development of more depressive (Kopala-Sibley *et al.*, 2016) and PTSD symptoms (Ogle *et al.*, 2016; Stevanovic *et al.*, 2016). In addition to an enhanced sensitivity to unpredictability and novelty, high neuroticism is also associated with an enhanced sensitivity to normative comparisons and negative emotions of others, also via media (Gibbons & Buunk, 1999; Jonkmann, Becker, Marsh, Lüdtke, & Trautwein, 2012; Van der Zee, Buunk, & Sanderman, 1996). Therefore, high neuroticism was expected to be associated with enhanced intra-individual increases in NA and somatic symptoms after the MH17 crash (H2b).

High conscientiousness taps into persistence, self-discipline, and the ability to self-regulate the expression and persistence of emotional experiences (Gross, Sutton, &

Ketelaar, 1998; Komulainen *et al.*, 2014). High conscientiousness is associated with higher PA and lower NA (Steel *et al.*, 2008), and successful coping behaviours (Connor-Smith & Flachsbart, 2007; John *et al.*, 2008; Moffitt *et al.*, 2011). For more conscientious people, we expected smaller intra-individual changes in PA, NA, and somatic symptoms after the MH17 crash (H2c).

Lifespan perspective

Another factor that may explain differences in the intensity of responses to the MH17 crash is age. People tend to become more emotionally stable, conscientious, and introverted throughout adulthood (Roberts, Walton, & Viechtbauer, 2006). This maturational trajectory of changing inner states is associated with an information processing bias towards positive versus negative information in older people (Reed, Chan, & Mikels, 2014), and an opposite pattern in younger adults, also known as the 'socio-emotional selectivity theory' (Carstensen, Fung, & Charles, 2003). Elderly also spend less time in social company and with media than younger people (Birditt, Fingerma, & Almeida, 2005; Wrzus, Wagner, & Riediger, 2015). These observations underlie our expectation that elderly experience weaker responses after the MH17 crash (H3), which would also correspond with the broader disaster literature (Ahern *et al.*, 2004; Holman *et al.*, 2014; Pfefferbaum *et al.*, 2001).

Media exposure

As exposure to media coverage of disasters can amplify the emergence of symptoms of stress and depression (Ahern *et al.*, 2004; Pfefferbaum *et al.*, 2001), media exposure might also increase affective and somatic responses. The emergence of smartphones and Internet-based social media (e.g., Facebook, Twitter, WhatsApp) over the past decade transformed news into a participatory experience in which people follow 'unfiltered' updates of the unfolding events via detailed video footage, in-depth stories about victims, and comments on causes and consequences (Hermida, 2010). Such 'ambient journalism' may further amplify the impact of vicarious disaster experiences, as media amplify the risk signal through the sheer volume of coverage and selective content (van den Brink, 2015; Kasperson *et al.*, 1988). This may result in what Tinbergen (1951) coined a 'supernormal stimulus', which can even surpass direct visual exposure in impact. Previous studies showed that extensive post-disaster television viewing enhanced the stress response when confronted with a disaster and that emerging symptoms in turn also enhanced participants' media consumption (Ahern *et al.*, 2004). Based on these previous studies, we expected media exposure to associate with more intense affective and somatic changes after the MH17 crash.

The present study

The available data in this serendipitous study allowed us to test (1) whether there were within-person changes in affect (PA/NA) and somatic symptoms after the MH17 crash, and (2) whether individual differences in the intensity of the responses were associated with personality traits, age, and media consumption. Participants were expected to respond to the MH17 crash with increased NA (H1a), decreased PA (H1b), and more somatic symptoms (H1c). The intensity of this response was expected to be moderated by personality, such that participants who scored higher on extraversion decreased less in PA

and showed a smaller rise in NA and somatic symptoms (H2a). For high neuroticism (H2b) and low conscientiousness (H2c), we expected more intense responses: larger decreases in PA, larger increases in NA, and more somatic symptoms. Finally, elderly participants were expected to be less responsive to vicarious disasters (H3), whereas more media consumption was expected to be associated with a stronger response (H4). Although these hypotheses were based on the literature and formulated and archived before the data became available (see van der Krieke *et al.*, 2015), they can be seen as exploratory given that the HowNutsAreTheDutch study was not designed for this paper.

Methods

Participants

The sample consisted of individuals from the general Dutch population who took part in the ongoing online 'HowNutsAreTheDutch' diary study, which started at 22 May 2014 (see van der Krieke *et al.*, 2015, 2016 for sampling details). The study from which our participants were selected covered both a diary study and a cross-sectional study and all measures can be found in van der Krieke *et al.* (2015). Before starting the diary study, all participants stated that they were at least 18 years of age, had a smartphone, were not engaged in shift work, did not anticipate a major disruption of daily routines within the study period, and approved of having their anonymous data used for research purposes. For the present study, we selected those participating in the diary study at the moment of the MH17 crash ($n = 141$). For 89 of these 141 participants, personality data were available.

These 141 participants who participated in the diary study at the moment of the MH17 crash ranged in age from 19 to 71 (see Table 1 for details). The total number of diary observations of the 141 participants was 8,149. The majority of participants was female ($n = 102$, 72%), in a romantic relationship (72%), and highly educated (high: 83%, middle 12%, low: 5%), in line with the distribution of the total HowNutsAreTheDutch sample (van der Krieke *et al.*, 2015, 2016). Diary participants were also comparable to the total study sample ($n = 15,000$) as regards extraversion and conscientiousness, but scored significantly higher on neuroticism ($d = 0.25$, $p < .001$) than those who did not participate (see van der Krieke *et al.*, 2015, table S5). The study protocol was approved by the Medical Ethical Committee of the University Medical Center Groningen (registration number M13.147422).

Procedure

Participants were recruited by means of a crowdsourcing procedure. Individuals from the general population of the Netherlands were invited to participate in a study of mental health as a dimensional and dynamic phenomenon by means of radio and television broadcasts, podium discussions, and articles in newspapers and magazines. The website www.hoegekis.nl (www.hownutsarethedutch.com) enabled participants to self-assess their mental health in a cross-sectional study, a longitudinal diary study, or both. In the diary study, participants monitored their feelings, behaviours, cognitions, and activities three times a day over 30 consecutive days (max. 90 assessments) using an electronic diary on their smartphone. Links to the diary questionnaire were sent by means of a text message at equidistant time points in the morning, afternoon, and evening, for example, at 10.30 am, 4.30 pm, and 10.30 pm, respectively. The exact time points depended on the

Table 1. Demographic and personality characteristics of the participants

	Total sample	Personality sample
N	141	89
Age, mean (SD)	43.6 (14.0)	45.2 (14.6)
Female, n (%)	102 (72%)	61 (69%)
Level of education, mean (SD) ^a	7.0 (1.1)	7.1 (1.1)
Number of observations, mean (SD)	57.8 (27.6)	61.1 (25.5)
Negative affect, mean (SD)	29.0 (19.3)	29.5 (18.9)
Positive affect, mean (SD)	55.8 (18.1)	56.3 (17.9)
Somatic symptoms, mean (SD)	25.0 (26.2)	27.5 (27.6)
Personality, mean (SD)		
Neuroticism		35.0 (9.8)
Extraversion		38.4 (7.5)
Conscientiousness		42.0 (6.8)

Note. ^aEducational level ranged from 1 (elementary school not finished) to 8 (academic degree).

participants' sleep–wake schedule but were always 6 hr apart. The diary questionnaire contained 43 items (van der Krieke *et al.*, 2015, 2016), but in the present study we only used the items for affect, somatic symptoms, and media use. Study materials and protocols are available in van der Krieke *et al.* (2015, 2016) and the scripts in an online supplement (DOI: 10.13140/RG.2.2.26550.34885). Under the General Data Protection Regulation 2016/679, our dataset is considered pseudonymized rather than anonymized, and is still regarded as personal data. Given that participants have not given informed consent to have their personal data publicly shared, we are legally and ethically not allowed to publicly post our dataset. Data is therefore only available from the first author upon request.

Diary measures

Affect

Momentary PA and NA were each measured with six items from the circumplex model of affect (Barrett & Russell, 1998; Yik, Russell, & Barrett, 1999). Participants rated the extent to which they felt relaxed, energetic, enthusiastic, content, calm, and cheerful (for PA) and gloomy, anxious, nervous, irritable, dull, and tired (for NA) on visual analogue scales (VAS) ranging from 0 (*not at all*) to 100 (*very much*), which we adapted from a previous ecological momentary assessment (EMA) study (Csikszentmihalyi & Larson, 1987). The composite PA and NA scores were calculated by taking the mean of the six mentioned items (range: 0–100). The internal consistency was computed using the deviations from the person mean of each item and was found to be good for the PA scale ($\alpha = 0.86$) and acceptable for the NA scale ($\alpha = 0.71$).

Somatic symptoms

Somatic symptoms were assessed with a single item that read 'I experience physical discomfort (e.g., headache, diarrhoea, heavy legs, etc.)' (VAS, 0–100), which we adapted from a previous EMA study (Csikszentmihalyi & Larson, 1987) and has been used in a number of other studies (Schenk, Bos, Slaets, de Jonge, & Rosmalen, 2017; van der Krieke *et al.*, 2016).

Media exposure

The diary item 'How did I spend most of my time over the past measurement period' included a multiple-choice of 13 categories including two reflecting media exposure (watching tv, surfing the web). The responses to these latter categories (coded 0/1) were combined and used as a time-varying variable in the models.

Moderator variables

Personality

Personality was assessed with the updated and shortened 60-item NEO-Five-Factor Inventory (NEO-FFI-3; De Fruyt & Hoekstra, 2014), with 12 items for each domain (e.g., 'I often feel stressed or tensed' for neuroticism, 'I smile easily' for extraversion, and 'If I made a promise, people can count on me' for conscientiousness). Items were scored on a five-point Likert scale, ranging from (1) 'strongly disagree' to (5) 'strongly agree'. Internal consistencies of these scales were good in this sample (van der Krieke *et al.*, 2015).

Statistical analysis

Three different multilevel models were fit to examine PA, NA, and somatic responses to the MH17 crash. The response was modelled as a level change that lasts x days and halves at day $x + 1$, to return to zero thereafter. The event variable was coded as 1 at the evening of the MH17 crash and the following x days, 0.5 at day $x + 1$, and 0 at all other measurement occasions. Different lengths of x , up to 7 days, were tested to determine the duration of the affective response to the event. The day of national grief (6 days after the crash) is included in this period. A random intercept and a random effect for the event variable were included in all models. The best-fitting model was selected based on the Bayesian information criterion (BIC).¹ Because Dutch women typically report higher neuroticism and conscientiousness and lower extraversion levels than men (Schmitt, Realo, Voracek, & Allik, 2008; van der Krieke *et al.*, 2015), all models were adjusted for gender differences.

To examine the moderating effect of age, media exposure, and personality, we added the moderator variables and the interaction between these variables and the event variable to the best-fitting models identified in the first step. We used multivariable models, in which all moderator variables were included at the same time, because there were several interdependencies among the moderator variables, such as higher age being associated with lower neuroticism. To enhance the interpretability of the main effects, the moderator variables were centred at their grand mean. The models on the moderation effects were adjusted for gender. Bootstrapped 95% confidence intervals with 1,000 replicates are presented, which are asymmetric, reflecting the asymmetry in the sampling distribution, which may lead to confidence intervals that do not contain the parameter estimates (see Reiser, Yao, Wang, Wilcox, & Gray, 2017).² Analyses were performed using SPSS Statistics

¹ BICs are only useful to compare different models and their absolute values do not convey any information. For this reason, we do not report them.

² We double-checked all analyses, and ran them again in Stata 15, and with a different seed, but the results remained the same.

25 (IBM, SPSS Inc., Chicago, IL). A p -value of .05 was used for statistical significance. The high number of assessments ensured sufficient statistical power for our main effects.³

Results

Affective and somatic symptoms

Table 2 shows the models for the effect of the MH17 crash on NA, PA, and somatic symptoms. For all three outcomes, the best-fitting model for the effect of the crash was the model with an effect that lasted 2 days, decaying by half at the third day after the crash, to become zero thereafter (see Figure 2; ... 000 001 111 111 0.5/0.5/0.5 000 000...). The crash had a significant effect on all outcomes; participants reported increased levels of NA, decreased levels of PA, and increased levels of somatic symptoms. The largest effect size was observed for somatic symptoms ($B = 2.78$) as this level was 2.78 points higher on average in the days directly after the crash than at other days during the study period (effect size $d = 0.11$, calculated by dividing the regression coefficient by the standard deviation of the outcome measure). Effect sizes for NA ($d = 0.04$) and PA ($d = 0.07$) were smaller. Significant heterogeneity in the MH17 effect was observed, as indicated by the random effects, which was especially large for the effect on somatic symptoms.

Moderating effects of personality, age, and media exposure

The multivariable models on the moderating effect of personality, age, and media exposure on the effect of the MH17 crash showed a number of significant interaction effects, which differed for each outcome (see Table 3). The moderating effect of the personality factors was only significant in the model for the PA response, as the decrease in PA after the crash was stronger in participants higher on extraversion ($B = -0.19$), but weaker in participants higher on neuroticism ($B = 0.16$) and conscientiousness ($B = 0.17$, all $p < .05$).

The impact of the MH17 crash on the rise in NA was significantly suppressed in older participants (NA*Age, $B = -0.11$, $p = .003$). The main effect of the MH17 crash was 2.13 in this model, which means that the 'average' participant of age 44 was 2.13 points higher on NA ($d = 0.11$) in the days directly after the crash than at other days during the study period. In participants who were 20 years younger than the average (i.e., age 24), the MH17 crash resulted in an increase in NA of $2.13 + (-20 * -0.11) = 4.33$ points (which amounts to $d = 0.22$).

Although the main effect of media exposure was significant in all three models (thus more media exposure was associated with more NA, less PA, and less somatic symptoms), no significant moderating effects of media exposure on the effects of the MH17 were found.

³ Although an exact sample size calculation is complex in the present situation (a multilevel model with several unknown parameters to estimate a within-subjects effect of a time-varying exposure, see Usami, 2014), a conservative sample size calculation was done with the power module of Stata. This showed that $2 \times 28 = 56$ participants would be sufficient to detect a moderate between-subjects effect ($d = 0.50$) with a power of 0.90, using an alpha level of 0.05, an intraclass correlation of 0.30, and 58 time points (i.e., the average number of completed observations). Since the power to detect a within-subjects effect is always higher than the power to detect a between-subjects effect, we expect our sample size of 141 (or 89 for the analyses with personality) to be sufficient.

Table 2. Multilevel models showing the effect of the MH17 crash on negative affect, positive affect, and somatic symptoms

	Negative affect			Positive affect			Somatic symptoms		
	Estimate	95% CI	p	Estimate	95% CI	p	Estimate	95% CI	p
Fixed effects									
Intercept	28.93	28.43–29.19	<.001	56.13	55.80–56.51	<.001	25.33	24.55–25.79	<.001
MH17 event	0.79	0.03–1.56	.022	-1.35	-2.19 to -0.47	<.001	2.78	1.59–4.05	<.001
Random effects									
Intercept	229	224–242	<.001	173	170–185	<.001	382	372–410	<.001
MH17 event	37.45	39.66–71.10	<.001	46.40	48.06–83.54	<.001	106	106–197	<.001

Note. Bold denotes significant values ($p < .05$). Fixed effects are estimated coefficients (B). Random effects are variances. Confidence intervals (CI) are bootstrapped. All models covered 141 participants with 8,149 observations in total.

Discussion

This paper presented an exploratory study of responses to the MH17 airplane crash in 141 vicariously exposed inhabitants of the Netherlands. Six key observations merit discussion. First, the MH17 crash elicited a small rise in NA and somatic symptoms and a decrease in PA. Second, this response lasted about 3 days (on average), corresponding with previous observations of public responses to vicariously experienced disasters (Cohn *et al.*, 2004; Strand, Mukamal, Halasz, Vatten, & Janszky, 2016). Third, personality moderated the decrease in PA, but did not influence the rise in NA and somatic symptoms after the MH17 crash. The drop in PA was stronger in more extraverted and weaker in more neurotic and more conscientious people. Fifth, older people reported a smaller increase in NA (which rose to $d = 0.22$ in younger people). Finally, media exposure did not influence the effect. These observations are discussed in more detail below.

The meaning of the MH17 crash

The present study focused on the MH17 crash, one of the deadliest post-Second World War disasters involving Dutch inhabitants. In terms of salience characteristics, this event can be considered to have had a low to medium impact severity (see Table 4). Russian separatists killed 298 people about 2,600 km from the Dutch border, out of the blue. Because most of the MH17 victims were Dutch, a perceived similarity may have bolstered social identification ('it could have been me', *cf.*, Dixon *et al.*, 1993; Fitzpatrick & Wilson, 1999; Wayment, 2004), in line with Festinger's (1954) social comparison theory. The availability of a target for blame and anger (i.e., Russian separatists), but also the deaths of families and young children, the problems to get access to the area of the crash to collect the remains, may all have intensified the emotional response (see Table 4 and Tennen & Affleck, 1990). Shared identities and

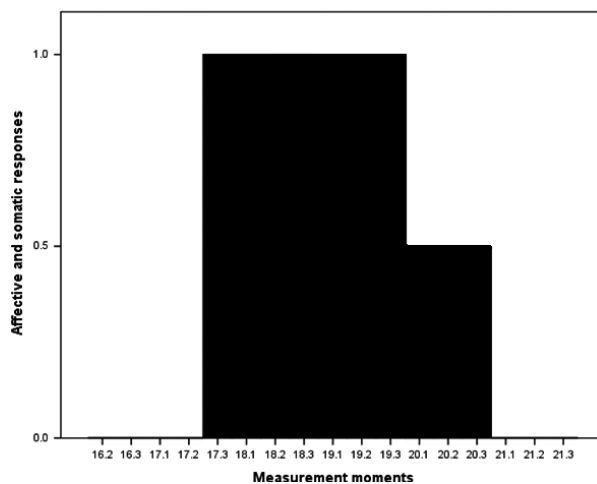


Figure 2. Affective and somatic responses to the MH17-crash.

Notes. This figure shows the best-fitting response shape. The x-axis shows the measurement moments, the morning (e.g., 17.1), afternoon (e.g., 17.2) and evening (e.g., 17.3) measurements between 16 July and 22 July.

Table 3. Multivariable multilevel models showing moderating effects of personality, age, and media exposure on the effect of the MH17 crash on negative affect, positive affect, and somatic symptoms

	Negative affect			Positive affect			Somatic symptoms		
	Estimate	95% CI	p	Estimate	95% CI	p	Estimate	95% CI	p
Intercept	30.70	29.80–31.70	<.001	53.30	52.30–54.30	<.001	28.17	26.80–29.50	<.001
Sex	1.69	0.69–2.55	<.001	0.08	–0.93 to 1.09	.871	–5.44	–6.71 to –4.04	<.001
MH17 event	2.13	–0.18 to 4.72	.062	–3.33	–5.81 to –0.79	.007	6.70	3.25–10.7	<.001
Neuroticism	1.01	0.97–1.06	<.001	–0.87	–0.93 to –0.81	<.001	0.93	0.85–1.01	<.001
Extraversion	–0.31	–0.36 to –0.24	<.001	0.38	0.30–0.43	<.001	–0.38	–0.47 to –0.29	<.001
Conscientiousness	–0.01	–0.08 to 0.06	.807	–0.10	–0.18 to –0.03	.007	–0.09	–0.18 to 0.01	.058
Age	0.05	0.02–0.08	.005	–0.13	–0.17 to –0.09	<.001	0.02	–0.04 to 0.06	.473
Media exposure	3.15	2.00–4.23	<.001	–4.64	–5.78 to –3.45	<.001	–1.61	–3.13 to 0.17	.038
MH17*Neuroticism	–0.01	–0.15 to 0.14	.918	0.16	0.02–0.30	.015	–0.14	–0.35 to 0.07	.135
MH17*Extraversion	0.03	–0.12 to 0.21	.636	–0.19	–0.36 to –0.02	.014	–0.18	–0.41 to 0.11	.132
MH17*Conscientiousness	0.05	–0.12 to 0.19	.486	0.17	0.01–0.36	.036	0.14	–0.13 to 0.38	.230
MH17*Age	–0.11	–0.19 to –0.03	.003	0.06	–0.01 to 0.14	.076	–0.04	–0.15 to 0.07	.466
MH17*Media exposure	0.14	–3.01 to 3.31	.940	–0.99	–4.32 to 2.27	.516	3.81	–1.40 to 9.13	.126

Note. Significant effects in bold. N = number of participants. Estimated coefficients are fixed effects. Moderator variables are centred around their mean. Sex is coded 0 (female) and 1 (male). All models covered 89 participants and 5,633 observations in total. CI= confidence interval.

Table 4. Salient disaster characteristics applied to the MH17 crash

Salient disaster characteristics	MH17 crash characteristics
1. Direct or vicarious exposure?	– Vicarious disaster exposure (via media)
2. Proximity	– MH17 crashed in Ukraine, over 2,600 km from the Dutch border
3. Intentionality / mutability	+ On purpose, shot down by Russian separatists, after the EU sanctioned Russia for its role in Ukraine the day before the crash.
4. Human-made or act of nature?	+ Human choice
5. Degree of life threat	– No direct threat to our participants, as they lived far from the disaster location
6. Death rate (exposure to death)	+ 296 victims
7. Physical injury	– No participant was injured
8. Proportion community affected (e.g., urban/rural)	– National response, but only few people were directly affected
9. Bereavement or loss of significant others	– Participants were unlikely to have lost close family members or friends
10. Speed of onset	+ Crash came ‘out of the blue’
11. Duration of the trauma	+ Short, but many return flights with bodies over the following months
12. Potential for recurrence (control)	– Small. Flights over Ukraine became suspended.
13. Severity of property destruction	– Relatively small on national scale (and no property of the participants)
14. Victim’s displacement from home	– Not applicable. Very slow recovery of victim bodies.
15. Person’s role in the trauma	– Absent
16. Organizational response to event (management)	+ Firm response from Dutch government, but difficulty securing victim bodies.
17. Sociocultural context of the event (understanding)	+ Exceptional event for the Netherlands and excessive media coverage. US President Obama broadcasted the MH17 crash as a ‘global tragedy’

Note. These characteristics were derived from review papers on disaster impact by Kasperson *et al.* (1988), Rubonis and Bickman (1991), Bromet and Dew (1995), and Neria *et al.* (2008). km = kilometres (0.62 mile).

emotions enhance social amplification and empathic transportation after the misfortune of similar others (Green *et al.*, 2008; Kasperson *et al.*, 1988; Nummenmaa *et al.*, 2012), which may have led to feelings of sadness and grief (Bennett & Kelaher, 1993; Wayment, 2004). The psychosomatic responses to the disaster we found in the present study illustrate the potential effect of sociocultural context, narratives, and beliefs on vicarious experiences (*cf.* ‘attack on the Netherlands’).

Disasters and terrorism typically trigger symptoms of depression and/or anxiety and somatic complaints (North & Pfefferbaum, 2013; Rubonis & Bickman, 1991; van den Berg *et al.*, 2005). Our results support this notion and extend relatively indirect evidence from studies by Truijens *et al.* (2015) and van Gelder *et al.* (2016), who found higher levels of depressive symptoms in pregnant women after the MH17 crash compared to controls assessed 1 year earlier, to a general population sample. Nonetheless, the observed affective-somatic change after the MH17 crash was relatively small, despite the massive emotional responses in the media (see van den Brink, 2015). The magnitude of the observed effects is common in media literatures (between $r = .10$

and .20, see Valkenburg, Peter, & Walther, 2016, p. 6) and may partly reflect strong individual differences in susceptibility to media effects, as illustrated by the size of the random effects. Another explanation is that the amount of vicarious exposure might have been limited in some participants since some people do not watch the news or read newspapers. Also, it might have been relevant that only a fraction of the Dutch population died, and there was low subsequent risk in the Netherlands, which are factors that are known to modify disaster impact (see Table 4). This may have limited feelings of personal involvement in our participants and may have allowed them to retain their sense of safety, which may explain the relatively small response and rapid emotional adaptation, especially relative to the reports for 9/11 (Keyes *et al.*, 2014; Thompson *et al.*, 2015).

Explaining individual differences in the impact of the MH17 crash

Personality moderated the drop in PA after the MH17 crash, but did not moderate the changes in NA and somatic symptoms. The drop in PA was slightly larger in more extraverted participants, contrary to our expectations. This unexpected finding might be explained by the fact that highly extraverted people had higher baseline levels of PA, thus more PA to lose. Also, extraverts typically focus on things outside the self, which may have focused their attention to the event. Furthermore, extraverts socialize more, thus may have talked more about the crash, which can bolster empathic transportation. A related possibility is that extraverted people need more social acts to maintain their PA levels (Berry & Hansen, 1996; but see Snippe *et al.*, 2017) and that these transactions were temporarily inhibited or less rewarding after the crash (Ellenbogen & Hodgins, 2004; Kamen, Pryor, Gaughan, & Miller, 2010; Ram *et al.*, 2005).

In contrast, extraversion did not moderate the rise in NA and somatic symptoms after vicarious exposure. These results are not in line with the reported protective effects of extraversion in the trauma literature (Ogle *et al.*, 2016; Stevanovic *et al.*, 2016). Extraverted sociability may still protect people after more severe and personal events (e.g., via social support, see Segrin, McNelis, & Swiatkowski, 2016), but may not be protective in the case of vicarious exposure to disasters.

Also against our expectations, the drop in PA after the MH17 crash was smaller in people higher on neuroticism. Similar to extraversion, this observation may reflect a restriction of range, as neurotics had lower levels of PA to begin with. However, it remains surprising that neuroticism seems to reduce the drop in PA and that there was no effect of neuroticism on the NA and somatic response. Neuroticism is commonly associated with an increased sensitivity to stress (Jacobs *et al.*, 2011; Jeronimus, Kotov, Riese, & Ormel, 2016; Komulainen *et al.*, 2014) and more persistent emotional reactions (Shackman *et al.*, 2016). Perhaps more neurotic people are only more reactive to *self*-related stressors and processing, and not to *non-self*-related experiences (Denissen & Penke, 2008). Hypothetically it may be that higher neuroticism still resulted in prolonged responses, but then this effect was too weak to observe in our sample.

As we expected, the drop in PA was smaller in more conscientious individuals, in keeping with heightened self-regulation abilities (effortful control, Komulainen *et al.*, 2014). Conscientious people may have kept themselves more strictly to their schedule despite the MH17 crash, which may have shifted their minds (e.g., via work) and yielded them more PA (Connor-Smith & Flachsbart, 2007). Similar to extraversion and neuroticism, conscientiousness had no effect on the NA or somatic response, in discord

with previous reports (Javaras *et al.*, 2012), and the notion of being more evenly tempered (Komulainen *et al.*, 2014).

Our results suggest that the broad personality domains are of little importance in predicting differences in vicarious exposure effects. Because the stress was limited in size and duration, there was less room for individual differences to operate. Personality may be more influential under conditions of intense or enduring stress (Connor-Smith & Flachsbart, 2007). Moreover, personality differences typically predict about 10% of the variance in actual behaviour in a given instance (Costa & McCrae, 1992; Mischel, 1968), but maybe less in 'strong situations' which are highly structured by sociocultural context, instincts, and survival value (Carruthers, Laurence, & Stich, 2006; Cooper & Withey, 2009; Tooby & Cosmides, 2008).

In contrast with personality, age did moderate the association between the MH17 crash and the increase in NA. Our observation that the rise in NA elicited by the MH17 crash was smaller in older participants compared to younger participants concurs with our expectations. This finding corresponds with observations that people become more emotionally stable over the life course (Roberts *et al.*, 2006) as well as findings from the trauma literature (Ahern *et al.*, 2004; Holman *et al.*, 2014; Pfefferbaum *et al.*, 2001). One explanation for this finding might be that elderly implement more sophisticated coping strategies (Connor-Smith & Flachsbart, 2007, p. 1084) and/or focus less on negative stimuli, in line with the socio-emotional selectivity theory (Carstensen *et al.*, 2003; Reed *et al.*, 2014), which deserves more in-depth study in future work. Notably, age did not moderate the effect of the MH17 on the elicited response in PA and somatic complaints, which is contrary to our hypothesis.

Although more media exposure was associated with more NA, more somatic symptoms, and less PA, media exposure did not moderate the affective-somatic response. It should be noted that we used a rather crude approach to assess media exposure: media exposure was only covered when individuals indicated that this was their main activity over the past 6 hr. We lacked detailed data about the amount of media consumption, as this diary was not designed for this paper. Future studies might be advanced by including a continuous measure of time spent on different types of media in their diary.

Limitations

In addition to the limitations outlined above, there are several other limitations that should be taken into account when interpreting our study results. One limitation by design is that our results may have been influenced by lowered or heightened scores during the period before or after the event, due to other collective or personal events. For example, the loss of the semi-final soccer during the world cup (9 July) may have suppressed the mood of the Dutch before the MH17 crash on 17 July. This suggests that our estimation of the MH17 effects is conservative at best. Furthermore, the study was conducted in an inherently 'noisy' environment in which each person might have experienced other stressful or positive events that may have resulted in a rather heterogeneous response. This also suggests that our estimation of the MH17 effects is conservative. Third, this paper presents an exploratory study of phenomena that cannot be studied in a lab, and thus, an observational design is the best we have. The use of a website to sample self-selected participants resulted in an overrepresentation of higher educated women and underrepresentation of healthy low-educated young men (see van der Krieke *et al.*, 2015 for a detailed comparison with the general Dutch population and two large longitudinal population samples). It might be expected that those who decide to participate are

disproportionally concerned about their mental health and possibly more susceptible to stress or more introspective than the average Dutch adult, although the reported symptom levels were fairly comparable with Dutch population studies (van der Krieke *et al.*, 2015).

Another limitation pertains to our assessment of emotions. Although we assessed both high and low arousal negative emotions, we did not assess some emotions that might specifically be elicited when vicariously exposed to disasters, such as anger and rage, or mixed emotions (Russell, 2017). Somatic complaints were assessed with one single item (see method section) which makes it difficult to judge its psychometric properties. As this diary item was assessed 90 times, it is less important for most analyses to have multiple-item scales than in traditional studies (Csikszentmihalyi & Larson, 1987, p. 531). Somatic complaints would ideally have been assessed with multiple items but it would also be quite burdensome for participants to fill out multiple-item scales repeatedly. Further, it has been shown that single items often capture similar information as scales do (e.g., Bergkvist, 2014; Bergkvist & Rossiter, 2007; Diamantopoulos, Sarstedt, Fuchs, Wilczynski, & Kaiser, 2012; Elo, Leppänen, & Jahkola, 2003; Rossiter, 2002; Wanous, Reichers, & Hudy, 1997).

Finally, the relatively small sample impeded a reliable replication of subgroup differences, such as higher intensity responses in women and people with pre-existing psychiatric problems (Bromet & Schulberg, 1987; Schuster *et al.*, 2001), or among people who experienced childhood trauma (Jeronimus *et al.*, 2013).

Conclusion

This diary study in the Dutch population showed a 3-day affective-somatic response to a vicariously experienced disaster, while participants were unlikely to know someone involved, and their own safety had not been threatened. Over 3 days, participants showed less PA, more NA, and most markedly, a rise in somatic symptoms. The effect sizes were small, which probably reflects a health emotional response. Personality moderated the change in PA but not in NA or somatic symptoms. Elderly were less sensitive to vicarious exposure as the rise in NA after the MH17 crash was smaller in older people. These results illustrate the potential immediate spreading power of vicarious disaster experiences in the form of a small acute stress reaction, even when an event takes place more than 2,600 km away.

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