AMERICAN PSYCHOLOGICAL ASSOCIATION

International Journal of Stress Management

ISSN: 1072-5245

2024, Vol. 31, No. 1, 56–65
https://doi.org/10.1037/str0000308

Does Armed Conflict Exposure Predict Psychotic Experiences in the General Population? An Experience Sampling Study

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There is mounting evidence that exposure to psychological stress and trauma increases risk of subsequent psychotic experiences (PE). However, we lack a clear understanding of the relationships between histories of trauma, stressful events in adulthood, and PE. In the present study, our aim was to investigate whether trauma history augments the risk of experiencing PE when exposed to later stressors in adulthood. We sought to address this by examining the relationship between exposure to rocket-warning sirens and PE during the 2014 Israel–Gaza conflict, using experience sampling. Our sample consisted of 97 healthy Israeli civilians who reported their experiences via smartphone twice daily for 30 days. We conducted multilevel models with time and siren exposure as predictors to estimate PE during the conflict. Siren exposure elicited PE, and PE decreased over time as the conflict persisted. People who had experienced previous trauma in adulthood were more likely to have PE when exposed to sirens compared with people who had experienced childhood trauma. Our current findings are broadly consistent with contemporary models of psychosis, which suggest that stress is involved in its aetiology and could have important implications for early detection and intervention in psychosis.

Keywords: psychotic experiences, stress, trauma, experience sampling, general population

Supplemental materials: https://doi.org/10.1037/str0000308.supp

There is evidence that experiencing psychological trauma increases the risk of psychosis, a potentially devastating condition associated with increased mortality and 10–20 years shorter life expectancy compared with the general population (Laursen, 2011). Psychotic experiences (PE), including hallucinations and delusions, are characteristic of psychotic disorders. However, fleeting and nondistressing hallucinations and delusions are also found in approximately 5%–10% of the general population that do not meet diagnostic criteria for a psychotic disorder and are considered subclinical (Linscott & van Os, 2013; McGrath et al., 2015). PE are seen as features of psychotic disorders only when they co-occur with other symptoms of the disorder; thus, causing impairment and distress (Legge et al., 2019).

While the vast majority of PE are transient and occur in the absence of other symptoms of psychotic disorders, 7.4% of affected individuals proceeded to develop psychotic disorders within a 2–15 years' time frame (Linscott & van Os, 2013). Since PE indicate increased risk of psychotic disorder, it is critical to understand the mechanisms underlying the association between trauma and PE. Targeting these mechanisms can help to identify individuals at high risk of psychosis and develop secondary prevention strategies; thus, aiding early intervention and improving treatment outcomes

This article was published Online First December 7, 2023.
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Talya Greene received funding from the Brain and Behavior Research Foundation under Narsad Young Investigator Grant 23524; Talya Greene and Marc Gelkopf received funding from the Israel Science Foundation 1244/16; Talya Greene and Marc Gelkopf received funding from the Moshe Hess Foundation; Marc Gelkopf received funding from NATAL: Israel Trauma and Resiliency Center. There are no conflicts of interest to declare.

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(Bloomfield et al., 2020). However, our understanding of these mechanisms remains limited.

Various aetiological and pathophysiological models of psychosis (Garety et al., 2001; Howes & Murray, 2014; Read et al., 2014; Zubin & Spring, 1977) propose stress as a mechanism linking environmental risk factors, including childhood trauma (Varese et al., 2012), to psychosis. Likely biopsychological mechanisms underpinning this association include the dopamine system (Bloomfield et al., 2019; Dahoun et al., 2019; Egerton et al., 2016). According to the stress-vulnerability model, psychosis occurs in individuals with a vulnerable predisposition of biopsychosocial origin, following stressors (Nuechterlein & Dawson, 1984; Zubin & Spring, 1977). The traumagenic neurodevelopmental model extends this theory by suggesting that neurodevelopmental changes following childhood trauma contribute to psychosis vulnerability through increasing sensitivity to daily life stress (Read et al., 2014). The cognitive model of delusions suggests that individuals who have experienced trauma develop dysfunctional schemas and cognitive biases, which increase paranoid attributions in ambiguous or stressful situations (Garety et al., 2001). While there is some evidence in support of these theories, the precise mechanisms underlying the role of stress in psychosis remain unclear due to inconsistent findings and methodological limitations of previous studies (Phillips et al., 2007).

Traditional approaches to investigate the relationship between stress and PE have focused on life events associated with the onset or relapse of psychotic disorders (Phillips et al., 2007). Life events can be defined as "situations or occurrences that bring about a positive or negative change in personal circumstances and/or involve an element of threat" (Beards et al., 2013, p. 740). A meta-analysis of 13 studies found that people who displayed PE were three times more likely to have experienced recent life events compared with controls (Beards et al., 2013). Although these findings suggest that stressful life events may increase the risk of developing PE, there are several methodological limitations, which make it difficult to draw inferences regarding causality. Most studies were cross-sectional, did not include a comparison group, and life events were reported retrospectively.

More recent experimental approaches to test the stress-vulnerability and traumagenic models have demonstrated increased levels of PE in clinical samples exposed to a busy shopping street (Ellett et al., 2008; Freeman et al., 2015) and to interpersonal stressors in a virtual reality environment (Valmaggia et al., 2015; Veling, Counotte, et al., 2016). Virtual reality studies also demonstrated that childhood trauma was associated with higher levels of PE in response to interpersonal stressors (Valmaggia et al., 2015; Veling, Pot-Kolder, et al., 2016). Taken together, these findings indicate that interpersonal stressors contribute to higher levels of PE and that stress sensitivity may be a plausible mechanism linking childhood trauma to psychosis. However, the virtual reality environment lacks ecological validity, which reduces the robustness of the findings.

We sought to address the limitations of previous cross-sectional and experimental research by using experience sampling methods to examine the stress vulnerability and traumagenic models. Experience sampling is an intensive longitudinal assessment method used to investigate people's mood, behaviors, and experiences in daily life (Myin-Germeys & van Os, 2007). Participants are asked to provide data at least once a day over a set period, often using mobile technology. A major strength of experience sampling is that it provides longitudinal data and enables investigation of within-person variation over time. The method also has high ecological validity as it studies people in their own environment and is less vulnerable to recall bias since it assesses experiences in real time (Myin-Germeys et al., 2009).

Previous experience sampling studies revealed that individuals at high risk of developing psychosis and people with psychotic disorders displayed higher stress sensitivity to everyday stressors compared with healthy controls (Lataster et al., 2013; Myin-Germeys et al., 2001; Palmier-Claus et al., 2012). In addition, increased stress sensitivity was associated with higher intensity of PE (Myin-Germeys et al., 2005; Reininghaus, Gayer-Anderson, et al., 2016). Consistent with the traumagenic model, individuals with psychotic disorders who had experienced childhood trauma displayed higher levels of PE in response to stressors (Lardinois et al., 2011; Reininghaus, Kempton, et al., 2016). Considering this effect of childhood trauma, it could be speculated that trauma exposure in adulthood also contributes to psychosis vulnerability through heightened stress sensitivity (Read et al., 2003). One study found that people with psychotic disorders who had experienced more life events in adulthood exhibited higher emotional reactivity to daily life stress than people with fewer life events (Myin-Germeys et al., 2003). However, no previous study has investigated whether adulthood trauma contributes to higher levels of PE in response to stressors.

In experience sampling studies to date, stress sensitivity has been conceptualized as the subjective appraisal of everyday stressors, for instance, missing the bus or being involved in an activity that you are no good at (Myin-Germeys & van Os, 2007). Although this approach enables people to report the everyday events that they subjectively find stressful, which may be beneficial since people perceive stressors differently, the heterogeneity of everyday stressors makes it difficult to evaluate and compare stress sensitivity between people. Hence, there is a need to examine the effect of a more objective stressor on PE.

In the present study, we investigate the effect of armed conflict exposure on PE. Armed conflicts offer a unique context to study the relationship between stress, caused by an imminent significant threat, and PE. A few epidemiological studies have found an association between armed conflict exposure and PE (Keraite et al., 2016; Soosay et al., 2012). However, to our knowledge, there have not been any previous experience sampling studies that have investigated PE repeatedly at a daily level during an armed conflict.

We used experience sampling data from the 2014 Israel–Gaza conflict to assess the relationship between exposure to rocket-warning sirens and PE in Israeli civilians. The sirens warned of an impending rocket attack on a specific area and demanded an immediate response from those in the vicinity to urgently seek shelter. Hence, the sirens were associated with risk of immediate injury or death and can be argued to be objectively stressful to participants. Consistent with contemporary models of psychosis, we also investigated whether participants' trauma history affected their stress sensitivity and thus moderated the relationship between siren exposure and PE during the conflict. The rationale for using a general population sample was to examine the effect of stress on subclinical PE, which could have important implications for early detection and intervention in psychosis.

Our study tested three hypotheses. First, that participants would experience more intense PE in assessment windows in which they were exposed to stress by hearing rocket-warning sirens compared with windows in which they were not exposed to sirens. Second, to test the stress-vulnerability model, we hypothesized that participants with higher levels of previous trauma exposure would experience more intense PE in assessment windows with siren exposure. Third, to test the traumagenic model, we predicted that in assessment windows with siren exposure, participants who had experienced their most distressing traumatic event in childhood would experience more intense PE, compared with participants who had experienced their most distressing traumatic event in adulthood.

Method

Procedure

Our study is part of a larger experience sampling study (Gelkopf et al., 2017; Greene, 2018; Greene et al., 2017, 2022; Lapid Pickman et al., 2017), which was conducted during and after the 2014 Israel–Gaza conflict. Data were collected from Israeli residents over a 50-day period, during which Gaza fired rockets and mortar shells toward Israel, and Israel conducted ground and air attacks on Gaza. When rockets were fired, warning sirens were sounded in the area under threat and residents had a time window of 15–90 s to seek shelter, depending on their distance to Gaza.

Participants entered the study between Days 8 and 24 of the conflict. After having completed the baseline questionnaire, they were sent experience sampling questionnaires to their smartphones via email twice daily for 30 days, at predetermined times in the morning and evening. They were asked to choose a time in the morning soon after they woke up and a time in the evening at the end of the day. The questionnaires assessed experiences that had taken place since the previous questionnaire. Participants were given a time window of 2 hr to respond to each assessment. The study design and procedure were approved by the University of Haifa Health and Social Welfare Faculty Ethics Committee (approval 179/14) and participants received 150 U.S. dollars for their participation.

Participants

The study was advertised on the websites of local organizations and communities, noticeboards in local colleges and universities, and on social media. People who wished to participate in the study contacted the research team by telephone to receive more information and to give their informed consent. They were also screened for the following inclusion criteria: (a) age ≥18 years, (b) resident in the area under threat within 90 s of a potential rocket hit, and (c) access to a smartphone. The exclusion criteria were current or past history of mental illness. Participants were asked in the telephone screening if they had ever been diagnosed with a mental illness. In addition, the baseline questionnaire asked participants to report if they (a) had previously received any psychiatric treatment, (b) were currently receiving any psychiatric treatment, or (c) had ever been hospitalized due to a mental illness. Hence, the sample consisted of adults without self-reported mental illness, who were residents in the area under threat and had access to a smartphone.

During the screening process, 114 people who contacted the researchers met inclusion criteria and agreed to participate in the study, 112 of these participants completed the baseline questionnaire, and 96 participants completed the 30-day experience sampling methods protocol. Sample size was determined based on resource constraints with a target of 100 participants.

Measures

Baseline Questionnaire

Demographics. Several demographic variables were collected, including age, gender, relationship status, education level, current employment, and financial status. Financial status was obtained by asking participants to rate their subjective status in relation to those around them.

Psychotic Experiences. PE at baseline was measured using a shortened version of the Community Assessment of Psychic Experiences (CAPE; Van Os et al., 1999). CAPE is a self-report measure consisting of 42 items assessing positive (20 items), negative (14 items), and depressive (eight items) dimensions of PE. Previous studies have shown that CAPE has good validity and reliability in nonclinical samples (Konings et al., 2006). Our CAPE version included 14 items, which specifically assessed positive PE (see Supplemental Materials A). For each item, respondents were asked to rate how often they had experienced PE on a 4-point Likert scale (1 = *never* to 4 = *nearly always*). The CAPE score was calculated as the sum score of the 14 items.

Trauma History. A modified version of the Trauma History Screen (THS; Carlson et al., 2011) was used to assess previous trauma exposure (see Supplemental Material B). Respondents were presented with a list of different types of traumatic events and were asked to report whether they had experienced any of them (yes/no). There is strong support for the validity and reliability of the THS in nonclinical community samples (Carlson et al., 2011). The THS score was the sum of the number of trauma types each respondent had experienced prior to the conflict. Participants were also asked to report at which age they had experienced their most distressing traumatic event but not the age at which each traumatic event occurred.

Experience Sampling Assessment

Psychotic Experiences. Hallucination intensity was measured with two items, "You hear voices that others don't" and "You see things that others don't." Delusion intensity was measured with three items, "You feel as if you lose control," "You feel that you cannot rid yourself of these bad thoughts," and "You feel suspicious of your surroundings." The validity and reliability of these items have been demonstrated in previous experience sampling studies in community settings (Oorschot et al., 2012). For each item, participants were asked to rate the extent to which they had experienced the symptom since the previous questionnaire on a 4-point Likert scale (0 = *not at all* to 3 = *a great deal*). The PE during conflict variable were calculated as the sum score of the five items assessing hallucinations and delusions.

Siren Exposure. Participants were asked whether they had experienced sirens since the previous assessment (yes/no).

Time. Each questionnaire that was sent to participants had an assessment number. The assessment number was cumulatively coded so that the first day, the first participant who completed an experience sampling assessment was coded as 1. The assessment

number increased with 0.5 for each subsequent questionnaire, regardless of whether the participant had completed the assessment. Hence, the assessment number could be used as a proxy for time.

Statistical Analyses

All statistical analyses were carried out using R Version 4.0.1 with RStudio (Version 1.3.959). Experience sampling data have a hierarchical structure in which repeated assessments (Level 1) are clustered within individuals (Level 2). We therefore conducted multilevel regression analyses to account for within-subject clustering of multiple observations. Given that the data violated the homoscedasticity and normality of residual assumptions (see Supplemental Materials C), we used multilevel logistic regression models as they do not require the residuals to be normally distributed or homoscedastic. We transformed the continuous outcome variable (PE intensity) into a binary variable, where 0 indicated absence of PE and 1 indicated presence of PE. Participants who had completed less than one third of the experience sampling assessments were excluded from the analysis, and an observed case analysis was performed on the remaining sample (Kimhy et al., 2012). We performed a multilevel regression analysis to assess whether any sample characteristics predicted the number of completed experience sampling assessments (see Supplemental Materials D).

Although a formal a priori power calculation was not conducted before data collection, a post hoc power analysis was performed using the EMAtools package (Kleiman, 2017). The power analysis used an estimated intraclass correlation coefficient of 0.4 based on previous models with the same data and demonstrated that a sample size of 96 participants was sufficient to detect a medium effect size ($d = 0.5$) with 80% power.

The multilevel models were performed using the lme4 package and included random intercepts and slopes for siren exposure and time, fit by maximum likelihood. To test our first hypothesis that siren exposure predicted increases in PE during the conflict, we built three multilevel models with PE as the outcome variable. Model 1 with siren exposure as the only predictor variable, Model 2 with siren exposure and time as predictors, and Model 3 with siren exposure and time, including an interaction between the two predictors. The three models were compared using the Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC), where lower Akaike Information Criterion and Bayesian Information Criterion values indicated better model fit. The best fitting model was used to predict PE during the conflict and was later adjusted for PE at baseline (CAPE score). In addition, we adjusted for age, gender, and financial status, as these variables have previously shown to be associated with PE (Linscott & van Os, 2013; McGrath et al., 2015).

To test our second hypothesis, we added trauma history (THS score) as a predictor to the best fitting model from the previous analysis and an interaction term between siren exposure and THS score. Last, to test our third hypothesis, we added the age of most distressing trauma exposure as a predictor to the model and assessed the interaction term between this variable and siren exposure.

Transparency and Openness

We report how we determined our sample size, all data exclusions, all analyses, and all measures in the study. This study's design and its analysis was not preregistered.

Results

Sample

Of the 112 participants who completed the baseline questionnaire, 15 participants (13.3%) who did not respond to at least 20 experience sampling assessments were excluded from the sample. Our final sample consisted of 97 individuals without self-reported mental illness (see Table 1), with complete data for the demographic variables measured at baseline. In terms of clinical variables, 97 participants reported the number of traumatic events they had experienced prior to the conflict, 95 participants (97.9%) reported their PE at baseline, and 65 participants (67.0%) reported the age of their most distressing traumatic event.

Participants completed 49 experience sampling assessments on average ($SD = 7.58$), and 80.8% and 81.0% of the responses for siren exposure and PE were valid, respectively. On average, participants reported hearing sirens in 29.76% ($SD = 16.92$) of the assessments. They reported PE both when they were exposed to sirens ($M = 1.64$, $SD = 2.45$) and when they were not exposed to sirens ($M = 1.13$, $SD = 1.98$) in the same assessment window. Eighty-three participants (85.6%) had experienced at least one traumatic event before the conflict started, and the mean age of experiencing their most distressing traumatic event was 19.20 years ($SD = 4.67$).

The Relationship Between Siren Exposure and PE

We conducted multilevel logistic regression analyses to investigate our hypothesis that siren exposure increases the odds of

Table 1
Demographic and Clinical Characteristics of the Sample (N = 97)

Sample characteristics	*n*	%	*M*	*SD*
Sex				
Male	28	29		
Female	69	71		
Relationship status				
Single	27	28		
In a relationship	28	29		
Married	40	41		
Divorced	2	2		
Education				
High school (no diploma)	5	5		
High school (with diploma)	34	35		
Higher education (including students)	54	56		
Other professional training	4	4		
Employment				
Full-time	32	33		
Part-time	13	13		
Temporary jobs	10	10		
Student	24	25		
Unemployed	5	5		
Other	13	13		
Financial status				
Below average	37	38		
Average	45	46		
Above average	15	16		
Age			30.09	8.99
CAPE score at baseline (14–56)			18.91	3.69
THS score at baseline (0–13)			2.02	1.42
Number of completed assessments			48.97	7.58
Percentage of assessments with siren exposure			29.76	16.92
PE score during conflict (person-mean; 0–15)			1.30	1.71

Note. CAPE = Community Assessment of Psychic Experiences; THS = Trauma History Screen; PE = psychotic experiences.

experiencing PE in the same assessment window. Of the models, Model 2 (siren exposure and time) was the best fitting model (see Supplemental Materials E) and was therefore used to predict PE during the conflict. The odds of experiencing PE were 32% greater when people were exposed to sirens in the same assessment window (see Table 2). There was also strong evidence of an overall negative effect for time where, for every day of exposure to the armed conflict, the odds of experiencing PE were 5% lower. When adjusting for age, sex, and financial status, the odds of experiencing PE in assessment windows with siren exposure were slightly attenuated (see Table 2). Nevertheless, the confidence intervals from the unadjusted and adjusted models largely overlapped, which suggests that the effect of the adjustment was minimal.

In the next stage of analysis, PE at baseline (CAPE score) were included as a predictor in the model. There was strong evidence that PE at baseline predicted PE during the conflict, where the odds of experiencing PE during conflict were 51% higher for every unit increase in CAPE score. When adjusting for CAPE score, the odds of experiencing PE in assessment windows with siren exposure were attenuated. However, there were no substantial differences in the results when adjusting for age, sex, and financial status, in addition to CAPE score (see Table 2). Our results indicate that people were more likely to have PE when they were exposed to sirens in the same assessment window, also after adjusting for demographic variables. Although this effect was attenuated when adjusting for participants' PE at baseline, there was still weak evidence which suggests that siren exposure increases the odds of experiencing PE.

The Moderating Effect of Trauma History on the Association Between Siren Exposure and PE

We performed multilevel logistic regression analyses to test our second hypothesis that people with higher levels of previous trauma exposure are more likely to experience PE in assessment windows with siren exposure. For this analysis, Model 2 was extended to include THS score as a predictor and an interaction between siren exposure and THS score.

When including THS score as a predictor in the model (see Table 3), there was still evidence of a main effect of siren exposure.

Table 2
Multilevel Logistic Regression Model Estimates for the Effects of Siren Exposure and Time on PE During Conflict

	Model 2			CAPE model		
Variable	*OR*	[95% CI]	*p*	*OR*	[95% CI]	*p*
Siren						
Unadjusted	1.32	[1.03, 1.69]	.028	1.25	[0.97, 1.61]	.085
Adjusted	1.31	[1.02, 1.67]	.033	1.25	[0.97, 1.61]	.090
Time						
Unadjusted	0.95	[0.93, 0.98]	<.001	0.96	[0.93, 0.99]	.002
Adjusted	0.95	[0.93, 0.98]	<.001	0.96	[0.93, 0.99]	.002
CAPE						
Unadjusted				1.51	[1.25, 1.83]	<.001
Adjusted				1.50	[1.24, 1.81]	<.001

Note. Adjusted odds ratio (*OR*) signifies that the model is adjusted for covariates (age, gender, and financial status). CAPE = Community Assessment of Psychic Experiences; PE = psychotic experiences; CI = confidence interval.

Table 3
Multilevel Logistic Regression Model Estimates for the Effects of Siren Exposure and Time on PE Moderated by THS Score

	THS model			THS model with interaction		
Variable	*OR*	[95% CI]	*p*	*OR*	[95% CI]	*p*
Siren	1.33	[1.04, 1.71]	.023	1.33	[1.04, 1.71]	.023
Time	0.96	[0.93, 0.98]	<.001	0.96	[0.93, 0.98]	<.001
THS score	1.63	[1.01, 2.63]	.046	1.59	[0.96, 2.65]	.071
Siren × THS[a]				1.02	[0.86, 1.22]	.788

Note. THS = Trauma History Screen; PE = psychotic experiences; CI = confidence interval.
[a] Interaction term between siren exposure and THS score.

There was also evidence of a main effect of THS score, where the odds of having PE during conflict were 63% greater for every unit increase in THS score. However, there was no evidence of an interaction effect between siren exposure and THS score.

Our results suggest that people who had experience more traumatic events before the conflict started were generally more likely to display PE during the conflict. However, the effect of siren exposure on PE did not change depending on how many different types of traumatic events participants had previously experienced. Stratified analyses for the low-trauma and high-trauma groups can be found in Supplemental Materials E.

The Moderating Effect of Most Distressing Trauma Age on the Association Between Siren Exposure and PE

We conducted multilevel logistic regression analyses to test our third hypothesis that people who had experienced their most distressing traumatic event in childhood are more likely to experience PE in assessment windows with sirens, compared with people who had experienced their most distressing event in adulthood. We added the age of most distressing trauma exposure as a predictor in Model 2 and an interaction between siren exposure and most distressing trauma age.

When we adjusted the model for people's age of most distressing trauma exposure (see Table 4), we found a main effect of most distressing trauma age. The odds of experiencing PE during conflict were 23% lower for every year increase in participants' age of most distressing trauma exposure.

We also found an interaction effect, which indicates that the effect of siren exposure on PE was moderated by participants' age of most distressing trauma exposure. As can be seen in Table 5, there was no evidence of an association between siren exposure and PE in the group who experienced their most distressing traumatic event in childhood. However, among participants who experienced their most distressing traumatic event in adulthood, the odds of experiencing PE were 63% greater in assessment windows in which they reported hearing sirens.

Our results indicate that people who had experienced their most distressing traumatic event at a younger age were generally more likely to experience PE during the conflict. However, people who had experienced their most distressing traumatic event in adulthood were more likely to display PE in assessment windows with siren exposure, compared with people who had experienced their most distressing traumatic event in childhood.

Table 4
Multilevel Logistic Regression Model Estimates for the Effects of Siren Exposure and Time on PE Moderated by Age of Most Distressing Trauma Exposure

	Trauma age model			Trauma age model with interaction		
Variable	*OR*	[95% CI]	*p*	*OR*	[95% CI]	*p*
Siren	1.19	[0.87, 1.64]	.271	1.26	[0.92, 1.73]	.144
Time	0.95	[0.93, 0.98]	.006	0.95	[0.92, 0.99]	.006
Trauma age	0.77	[0.63, 0.95]	.012	0.75	[0.61, 0.91]	.004
Siren × Trauma Age				1.08	[1.01, 1.16]	.035

Note. PE = psychotic experiences; CI = confidence interval.

Discussion

Summary of Findings

Our study used experience sampling to assess the concurrent relationship between rocket-warning sirens and PE during the 2014 Israel–Gaza conflict. In line with our first hypothesis, we found that people were more likely to experience PE in assessment windows in which they reported hearing sirens, and that PE decreased over time as the conflict persisted. Contrary to our second hypothesis, we did not find any evidence to suggest that people with higher levels of previous trauma exposure were more likely to experience PE in response to sirens. Finally, contrary to our third hypothesis, we found that people who had their most distressing trauma exposure in adulthood were more likely to experience PE in response to sirens, compared with people who had experienced their most distressing traumatic event in childhood.

Interpretations of Findings

Our study employed a novel and more objective experience sampling method to investigate the relationship between trauma history, current stressors, and PE over time. We found that people were approximately 25% more likely to experience PE in assessment windows with siren exposure, after adjusting for PE at baseline and several demographic variables. Our findings are consistent with experimental studies (Ellett et al., 2008; Veling, Counotte, et al., 2016) and experience sampling studies (Myin-Germeys et al., 2005; Reininghaus, Gayer-Anderson, et al., 2016), which demonstrated that stress exposure was associated with higher levels of PE in clinical samples. However, the effect of siren exposure on PE was slightly weaker compared with the association found between stress and PE in previous studies (Myin-Germeys et al., 2005; Reininghaus, Gayer-Anderson, et al., 2016), which may be due to our investigation of subclinical PE in individuals without self-reported mental illness. The effect of siren exposure on PE was attenuated after adjusting for PE at baseline. However, since participants entered the study between Days 8 and 24 of the conflict, their PE at baseline may already have been elevated due to previous siren exposure at the start of the conflict. Still, our finding that the effect of siren exposure remains even after adjusting for preexisting PE provides evidence that stress exposure had an additive effect on PE during the conflict. Crucially, our results indicate that stress can elicit PE in individuals with no self-reported history of psychosis.

Table 5
Multilevel Logistic Regression Stratified Analyses for Childhood Trauma and Adulthood Trauma Groups

	Childhood trauma (<20 years)			Adulthood trauma (≥20 years)		
Variable	*OR*	[95% CI]	*p*	*OR*	[95% CI]	*p*
Siren	1.00	[0.64, 1.58]	.988	1.63	[1.04, 2.55]	.033
Time	0.97	[0.93, 1.02]	.262	0.93	[0.88, 0.97]	.002

Note. CI = confidence interval.

We also found evidence of a habituation effect where PE decreased over time as the conflict persisted. It remains tentative whether this habituation effect is unique to armed conflict exposure or to contexts where people are exposed to the same stressor over time. If so, heterogeneous everyday stressors may have a more persistent effect on PE (Myin-Germeys et al., 2001, 2005; Reininghaus, Gayer-Anderson, et al., 2016). Moreover, different subgroups may have followed different PE trajectories during the conflict, as has previously been shown for posttraumatic stress disorder (PTSD) symptoms in the same sample (Greene et al., 2017). It remains to be investigated whether there are subgroups experiencing habituation of PE levels and others who do not. This could have important clinical implications for identifying high-risk groups who require psychological interventions.

We found that people with prior exposure to more trauma types were more likely to experience PE in general during the conflict. Our findings were broadly consistent with studies that have demonstrated a dose–response relationship between trauma and psychosis, where the likelihood of experiencing psychotic symptoms increases with the number of traumatic events (Shevlin et al., 2008). However, our results differed from previous experience sampling studies, which supported the stress-vulnerability model (Lardinois et al., 2011; Reininghaus, Gayer-Anderson, et al., 2016), since we found no evidence to suggest that people with higher levels of previous trauma exposure were more likely to experience PE in response to hearing sirens. Thus, although people who had experienced multiple traumatic events were generally more vulnerable to PE, they were not more likely to experience PE when exposed to specific momentary stressors.

We did not find any evidence to support our hypothesis that people who had experienced their most distressing traumatic event in childhood were more likely to display PE in response to sirens. Our findings were therefore inconsistent with the traumagenic neurodevelopmental model (Read et al., 2014) and previous studies, which found that people who had experienced childhood trauma were more stress sensitive and displayed higher levels of PE in response to stressors (Lardinois et al., 2011; Veling, Pot-Kolder, et al., 2016). However, our finding was partly consistent with one study, which demonstrated that healthy individuals who had been exposed to childhood trauma displayed lower levels of PE in response to stressors (Reininghaus, Kempton, et al., 2016).

Contrary to our predictions, these findings suggest that distressing adulthood trauma contributes to heightened stress sensitivity where later stressors elicit PE. A similar effect has previously been demonstrated for life events in adulthood (Myin-Germeys et al., 2003). One possible explanation for this finding is the temporal

proximity of trauma exposure in adulthood since the psychopathological impact of traumatic events may resolve naturally over time (Croft et al., 2019; McGrath et al., 2015). Recent trauma exposure related to previous armed conflicts in the area may also have primed civilians to experience stress when hearing sirens. Taken together, our results indicate that stress plays a role in the aetiology of psychosis, and that stress sensitivity may be a plausible mechanism linking trauma exposure in adulthood to psychosis.

There are several potential explanations for our unexpected findings that higher previous trauma exposure throughout the life span, and distressing childhood trauma, did not contribute to heightened stress sensitivity and increased PE levels. First, we measured trauma history differently. Previous studies employed the Childhood Trauma Questionnaire (Bernstein et al., 2003) that assesses the frequency of different childhood traumas rather than the number of trauma types which people had experienced throughout their lifespan (as measured by the THS). Other features of traumatic events (for instance frequency, duration, or impact), which were not captured by the THS, may be more pertinent to the stress sensitivity mechanism, which underlies the relationship between trauma and PE. It is also possible that certain trauma types, which the THS measures (for instance exposure to natural disasters or traffic accidents), are less relevant to the stress sensitive mechanism compared with the various forms of abuse and neglect measured by the Childhood Trauma Questionnaire.

Second, our results may have differed from previous studies since we investigated PE in individuals without self-reported mental illness. A neuroimaging study found that healthy individuals who had been exposed to chronic psychosocial adversity had a blunted physiological stress response to acute psychosocial stressors (Bloomfield et al., 2019). As suggested by this study, a healthy adaptive response to childhood trauma is to downregulate the stress response system. In contrast, it is possible that people with childhood trauma, who develop psychosis in response to stressors in adulthood, may instead have upregulated their stress response. We need future studies to test this hypothesis. Furthermore, there could be mediating factors that determine if an individual with higher levels of previous trauma exposure, including experiences of childhood trauma, develops psychosis in adulthood. A recent meta-analysis found that the relationship between childhood trauma and psychosis in adulthood was mediated by PTSD symptoms (Bloomfield et al., 2021). It is therefore possible that people who had developed PTSD symptoms following their childhood trauma were more likely to present with PE in response to stressors in adulthood.

An alternative explanation stems from our decision to investigate the relationship between armed conflict exposure and PE in a sample with high levels of previous conflict-related trauma. Only eight participants reported that they had never previously been exposed to rocket or terror attacks. Mass traumas like armed conflicts involve distinct individual responses compared with interpersonal traumas, some of which may serve as protective factors. For instance, it may be easier to externalize blame for the event and to receive support from others in the community since the trauma is shared (Center for Substance Abuse Treatment, 2014). Positive-parenting practices and supportive school environments can help children to develop resilience following adverse experiences, thus having a protective impact on their mental health (Betancourt & Khan, 2008; Collishaw et al., 2007; Gewirtz et al., 2008). It is possible that the cumulative impact of previous armed conflicts in the area, and associated protective factors, may have contributed to some individuals becoming more resilient to siren exposure (Betancourt & Khan, 2008; Greene et al., 2018; Siriwardhana et al., 2014). Individuals who had experienced multiple traumatic events and distressing childhood trauma related to previous conflicts may be particularly resilient to rocket fire and therefore, less likely to experience PE in response to sirens. Our findings may not be generalizable to other contexts where people are exposed to momentary stressors, which are distinct from their trauma history.

Strengths and Limitations

Our experience sampling methods approach has several strengths compared with other methodologies used to study the relationship between stress and psychosis, including high ecological validity, longitudinal data, and assessment in real time (Myin-Germeys et al., 2009). The 30-day protocol and large number of completed assessments ensured that the measurement of PE was robust and allowed us to study variability in PE over a longer period than previous experience sampling studies. A further strength of our approach was that we assessed trauma history throughout the life span, instead of solely focusing on the moderating effect of childhood trauma (Lardinois et al., 2011; Reininghaus, Kempton, et al., 2016).

Our findings should also be viewed in the light of several potential methodological limitations. Experience sampling is a time-consuming and demanding method to participants, which introduces a possibility of self-selection bias. Nevertheless, our study benefitted from low attrition. We found no demographic differences between people who completed the protocol and those who dropped out (Greene et al., 2017), indicating that the risk of attrition bias was low. Although our results suggest that stress is involved in the aetiology of psychosis, we cannot infer causality since we modeled the concurrent relationship between siren exposure and PE, and there may also be unmeasured confounders. However, we adjusted for several demographic variables and PE at baseline.

Our study did not measure subtle and heterogeneous interpersonal stressors, for example exposure to a busy shopping street, which may be highly relevant to the development of psychosis (Garety et al., 2001; Howes & Murray, 2014). Nevertheless, all participants were exposed to the sirens, which provided us with a unique opportunity to investigate habituation to an objective and aversive stressor over time.

Our data relied on subjective reports, which may lead to different interpretations of items. There is a risk of recall bias since participants reported their trauma history retrospectively. The THS version we used only assessed the age of the most distressing trauma exposure but not the age at which each traumatic event occurred. It is therefore possible that some people had experienced childhood trauma before their most distressing traumatic event in adulthood. However, there is strong support for the validity and reliability of the THS in the general population (Carlson et al., 2011).

PTSD was not measured at baseline as the conflict had been ongoing for more than a week (but less than a month) when data collection started; therefore, any measurement of PTSD symptoms

at baseline would be pretraumatic rather than posttraumatic. Hence, a limitation of our study is that we were unable to assess whether presence or absence of baseline PTSD symptoms mediated PE levels in daily life. Nevertheless, no participants disclosed having been diagnosed or treated for PTSD during the screening process.

The validity and reliability of the experience sampling PE items have previously been demonstrated in community settings. However, this was the first experience sampling study that investigated PE during an armed conflict, and therefore, a limitation of our study is that the PE items had not been validated in this specific context. It is therefore possible that the delusional items may be indicative of a normative fear response to being in a dangerous situation. However, participants also reported hallucinations during the conflict, often in the same time window as they reported delusions. Moreover, there was a strong relationship between baseline PE (measured by CAPE) and PE in daily life, which indicates predictive validity of the experience sampling PE items. Previous epidemiological studies in areas with armed conflict have employed the Psychosis Screening Questionnaire with similar hallucination and delusion items to the ones used in our study (Keraite et al., 2016; Soosay et al., 2012). Taken together, this provides support that our five PE items were valid and reliable in an armed conflict context.

Finally, our study may not have had sufficient power to detect an interaction effect since models with a cross-level interaction have substantially lower power compared to models without an interaction, using the same sample size (Mathieu et al., 2012). Hence, larger samples are required to fully investigate how the relationship between stress exposure and psychosis is moderated by trauma history.

Implications

Our findings have implications both for research and clinical practice. First, seeing that stress exposure plays a role in the early stages of psychosis, further work is needed to examine whether it may be beneficial to use psychological interventions preventatively to enhance stress management and resilience (Rose et al., 2013). Our findings tentatively suggest that these interventions may be particularly helpful for people who have experienced adulthood trauma, but we need to investigate this further by making clear distinctions between childhood trauma and adulthood trauma. Given the habituation effect of PE over the course of the conflict, future studies should also investigate whether exposure-based therapies may be effective for people with PE in the context of trauma. With the aim to develop more targeted interventions for psychosis, we also need to further understand the neurocognitive mechanisms underlying the relationships between trauma history, current stressors, and psychosis.

Our study's novel experience sampling approach raises questions regarding which stress measurement is more valid: subjective appraisals of how stressful people found heterogeneous everyday events (Myin-Germeys et al., 2005; Palmier-Claus et al., 2012) or assessments of a highly aversive stressor, which all participants were exposed to. Future methodological research is needed to optimize the choice of subjective and objective measurements in experience sampling studies. Finally, future work should integrate experience sampling with mechanistic research to understand how trauma relates to the characteristic alterations in brain structure and function that are observed in psychosis (Bloomfield et al., 2016).

Conclusions

Our findings indicate that individuals with no previous history of psychosis are more likely to experience PE when exposed to stress. We also found that previous experiences of trauma in adulthood made people more sensitive to experience PE, following stress exposure. Our findings were therefore broadly consistent with contemporary models, which suggest that stress may be an underlying mechanism linking environmental risk factors to psychosis (Garety et al., 2001; Howes & Murray, 2014; Nuechterlein & Dawson, 1984; Read et al., 2014). Further work is needed to understand the precise relationships between exposure to trauma and PE, alongside the biopsychosocial processes underpinning these relationships. It is critical that we develop and evaluate interventions which directly target these processes to reduce the risk of experiencing PE and prevent the onset of psychosis.

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Received December 20, 2022
Revision received August 29, 2023
Accepted September 3, 2023 ■