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Posttraumatic stress disorder in daily life among World Trade Center responders: Temporal symptom cascades

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ABSTRACT

Background: Posttraumatic stress disorder (PTSD) symptoms are common in the immediate aftermath of a trauma, but it is their persistence over time that leads to a diagnosis. This pattern highlights the critical role of symptom maintenance to understanding and treating the disorder. Relatively few studies have explored whether PTSD symptoms may be interacting or triggering one another to worsen and maintain the disorder, a dynamic we refer to as "symptom cascades." Additionally, little work has tested in real-time how other maintenance factors, such as stress, contribute to such events in daily life.
Methods: The present study in a group ($N = 202$) of World Trade Center (WTC) responders oversampled for PTSD tested day-to-day temporal associations among PTSD symptom dimensions (i.e., intrusions, avoidance, numbing, and hyperarousal) and stress across one week.
Results: Longitudinal models found hyperarousal on a given day predicted increased PTSD symptoms the next day, with the effect sizes almost double compared to other symptom dimensions or daily stress. Intrusions, in contrast, showed little prospective predictive effects, but instead were most susceptible to the effects from other symptoms the day before. Avoidance and numbing showed weaker bidirectional effects.
Limitations: Findings are from a unique population and based on naturalistic observation.
Conclusions: Results are consistent with the idea of symptom cascades, they underscore hyperarousal's strong role in forecasting short-term increases in PTSD (even more than stress per se) and they raise the prospect of highly specific ecological momentary interventions to potentially disrupt PTSD maintenance in daily life.

Post-traumatic stress disorder (PTSD) is a disabling condition, with a lifetime prevalence rate of about 7% in the general population and higher rates in certain groups at risk for trauma exposure (e.g., Kang et al., 2003; Kessler et al., 2005; Kulka et al., 1990). One of the most influential models of the disorder (King and King, 1994) describes four major types of symptom dimensions (i.e., intrusions, avoidance, numbing, and hyperarousal) that emerge and persist in the wake of a life-threatening trauma, although a robust literature has debated their precise contours and numbers (e.g., Armour et al., 2016; Pietrzak et al., 2015). Importantly, PTSD symptoms are not constantly present among those with the diagnosis or subthreshold symptoms, but instead can vary across time (McFarlane, 2000; Solomon et al., 2009) and even fluctuate widely from one day to the next (Black et al., 2016; Schuler et al., 2019).

Fluctuations in PTSD symptoms raise the possibility that symptoms may interact with one another to perpetuate or exacerbate the condition across time. For example, recurrent intrusive thoughts of a trauma may in turn trigger avoidance symptoms of the disorder. These in turn could prevent therapeutic exposure and disorder resolution, and thus maintain the condition over time. Such interactions - with one dimension of symptoms provoking/exacerbating another – might be termed "symptom cascades" and could represent dynamic interactions that maintain PTSD in some individuals, especially those with chronic forms of the disorder. Indeed, several trauma theories indirectly posit how such dynamics might unfold, although their timeframe and directionality

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remains speculative. For example, the Emotional Processing Theory (EPT) of PTSD (Foa and Kozak, 1986; Foa et al., 1989; Foa et al., 1992) proposes that activation of the fear association network by trauma reminders causes information in this network to enter consciousness, giving rise to PTSD intrusion symptoms. One might speculate then that avoidance symptoms increase as a maladaptive attempt to suppress the intrusions (reviewed in Dalgleish, 2004). Accordingly, one would expect intrusion symptoms to be the leading edge of any symptom cascade that unfolded over time.

Despite such theoretical speculation, empirical research has only recently begun using prospective data to directly test such symptom dynamics. An expanding literature has modeled networks of PTSD symptom interconnections (e.g., Armour et al., 2017; Bryant et al., 2017; McNally et al., 2017; Sullivan et al., 2018). However, these studies are overwhelmingly cross-sectional in nature, meaning they sidestep the core temporal relationships that are central to symptom cascades and to theoretical models of the disorder. A few other studies have used prospective data, but their assessments were years apart, whereas the theorized dynamics are likely to play out over a much shorter period of time. Nevertheless, these longitudinal studies are informative and have suggested, for example, that hyperarousal may be the most important symptom dimension for predicting future onset and maintenance of PTSD (Adams et al., 2019; Doron-LaMarca et al., 2015; Marshall et al., 2006; Pietrzak et al., 2014; Schell et al., 2004; Solomon et al., 2009). One study assessed participants on a weekly basis and found a similar importance of hyperarousal, as well as hypervigilance (Hoffart et al., 2019). In addition, this study also found lesser, but still significant, predictive abilities for avoidance and flashbacks.

In contrast to cross-sectional studies or studies with long intervals between assessments, ecological momentary assessment (EMA) or diary studies offer an ideal opportunity to investigate day-to-day symptom cascades, since symptoms are assessed repeatedly and without reliance on long-term recall that can introduce biases (Shiffman et al., 2008). To date, a number of EMA studies have been conducted in people with PTSD (e.g., Black et al., 2016; Possemato et al., 2015; Priebe et al., 2013), but only a few tested symptom cascades (Greene et al., 2018; Gelkopf et al., 2019; Price, Legrand, Brier, Gratton, & Skalka, 2020; Reeves and Fisher, 2020). Although these studies found evidence for cascading, the specific patterns differed. PTSD symptoms were found to best predict subsequent sleep disturbance, loss of interest, hypervigilance, and negative emotions in one study (Greene et al., 2018), and startle response, low interest, and external avoidance in another (Price et al., 2020). Conversely, startle response, blame, and restricted affect (Greene et al., 2018), as well as low interest, emotional reactivity, and sleep difficulties (Price et al., 2020) most strongly predicted subsequent PTSD symptoms (Greene et al., 2018). Another study of peritraumatic PTSD examined cascading of intrusions, avoidance, negative cognitions and mood (NCM), and arousal from day-to-day (Gelkopf et al., 2019). This study found that any given symptom on one day was likely to occur again on the following day. For example, intrusions predicted next-day intrusions, avoidance predicted next-day avoidance, and so on. Beyond this pattern, arousal predicted subsequent intrusions and NCM, and intrusions predicted next-day arousal. Avoidance and NCM did not demonstrate cascading with other symptoms. A fourth study also found evidence of cascading, but with minimal variation in PTSD symptoms predicting subsequent individual symptoms, and vice versa (Reeves and Fisher, 2020). Other studies have considered the effects of threat on symptoms (Lapid Pickman, Greene & Gelkopf, 2017). Importantly, none of these studies considered cascading effects between individual symptoms or day-to-day stress.

Identifying daily symptom cascades has the potential to change how we treat PTSD. Ecological momentary interventions (EMIs) provides services to clients between in-person sessions and in their natural environment (e.g., home; Myin-Germeys et al., 2016), but their effective development requires knowledge of factors that maintain PTSD, such as possible symptom cascades. Rather than focusing on PTSD as a unitary syndrome, the presence of cascades would suggest EMIs targeted at specific sets of symptoms in real-time might disrupt disorder expression, which in turn might impact longer-term course.

Given this background, the present study tested for the existence of day-to-day temporal cascades among PTSD symptom dimensions in a sample of World Trade Center (WTC) responders, many with chronic PTSD. WTC responders collectively faced major trauma during the rescue, recovery, and clean-up operations following the September 11, 2001 (9/11) attack (Bromet et al., 2016; Luft et al., 2012). Responders were exposed to human remains, body parts and fluid, witnessed death and destruction, and experienced the loss of friends, family, and colleagues (Luft et al., 2012). Consequently, PTSD is one of the most prevalent and persistent mental health conditions in this group (Bromet et al., 2016; Luft et al., 2012; Stellman et al., 2008; Wisnivesky et al., 2011). Even 11–13 years after the disaster, 9.7% of WTC responders continued to have current PTSD diagnoses, based on the Structured Clinical Interview for *DSM-IV* (Bromet et al., 2016). Identifying factors (including individual PTSD symptoms) that maintain PTSD in this population is crucial for understanding the disorder, as well as helping those who continue to experience symptoms years after the trauma.

In the present study, WTC responders were tracked daily for one week, with four types of PTSD symptoms (i.e., intrusions, avoidance, numbing, and hyperarousal) surveyed three times a day. Daily symptoms were aggregated, and day-to-day symptom cascades were modeled (i.e., effects of symptom changes from a given dimension on a given day were used to predict [1] next-day changes among other symptom dimensions, and [2] next-day changes in total PTSD severity). We hypothesized that hyperarousal would have the most pronounced effects on other PTSD symptoms as well as total PTSD given previous prospective work in long-term studies, but we acknowledge that theories discussed above would posit intrusions to play a leading role in any cascade. Finally, we examined effects of daily stress in triggering symptoms as both a point of contrast to the inter-symptom cascades themselves, as well as given the fact that much of the work on stress in PTSD has considered long term impacts (e.g., Zvolensky et al., 2015) rather than its daily toll.

1. Method

1.1. Participants

A sample of 202 World Trade Center responders ($M_{age} = 54.28$, $SD = 9.69$) was recruited from the Long Island site of WTC Health Program. The WTC Health Program is comprised of adults who were involved in the rescue, recovery, cleanup, and other support services related to the 9/11 attacks, providing these responders a number of healthcare

Table 1
Sample Characteristics.

Demographics	Total ($n = 202$)
Age (years)	54.28 (9.69)
	Range: 35-85
Education (years)	14.82 (2.26)
	Range: 6-28
Sex	
Male	167 (82.7%)
Female	35 (17.3%)
Race	
White	178 (88.1%)
Black	12 (5.9%)
Asian	1 (0.5%)
Multiracial	5 (2.5%)
Other	6 (3.0%)
Ethnicity	
Hispanic	33 (16.3%)
Non-Hispanic	163 (80.7%)
Unspecified	6 (3.0%)

services. Responders receiving care at the Long Island site were recruited during their annual visit. Table 1 provides demographics characteristics of the sample, which align with the characteristics of the WTC responder population. Participants were primarily male (82.7%, $n = 167$), White (88.1%, $n = 178$), and non-Hispanic (80.7%, $n = 163$), with an average of 14.82 ($SD = 2.26$) years of education. The majority of this sample were current or former police (62.9%, $n = 127$). More than half (56.4%, $n = 114$) of the participants arrived and responded in the dust cloud of 9/11, and 82.7% of the sample ($n = 167$) was exposed to human remains during their response. Most of the participants (82.7%, $n = 167$) were early arrival responders.

The study was designed to oversample for PTSD symptoms. PTSD severity quartiles were created based on the most recent PCL-5 scores from the WTC clinic, and consecutive patients from each quartile were invited to participate. As a result, 19.3% ($n = 39$) of the sample had a current PTSD diagnosis (double the rate in this population), but the sample as a whole (except for the lowest quartile) had elevated PTSD symptoms. In addition, 32 (15.8%) participants had a current diagnosis of Major Depressive Episode (MDE). Overlapping comorbid PTSD/Major Depressive Disorder (MDD) occurred in 20 (9.9%) of these participants. All participants provided informed consent and the study was approved by the Stony Brook Committees on Research Involving Human Subjects.

1.2. Procedure

Participants completed an in-person baseline assessment followed by seven days of thrice daily survey assessments (mid-morning, afternoon, and evening). At the baseline assessment, participants completed informed consent, demographic information, and a diagnostic interview. Over the next week, participants responded to the daily EMA surveys on an iPod provided by the team, with prompts prior to the predesignated assessment times. The average adherence rate was very high (i.e., 93.8% survey completion, with individual adherence rates for participants included in analyses ranging between 50% and 100% of the total surveys across the week).

1.3. Measures

Baseline PTSD diagnosis. The Structured Clinical Interview for *DSM-IV* (SCID; First et al., 1997) was administrated to all participants at the baseline assessment. The interviews were administrated by experienced Master-level interviewers, closely supervised by licensed clinical psychologists (C.R. and R.K.). Previous assessments of reliability of the trained interviewers in this population demonstrated very good inter-rater agreement ($\kappa = 0.82$; Bromet et al., 2016) for current PTSD diagnosis at baseline.

Daily PTSD symptoms. Eight items drawn from the PTSD Checklist for *DSM*-5 (PCL-5; Weathers et al., 2013) were used to assess PTSD symptoms in the thrice daily EMA surveys. Participants were asked to rate PTSD symptom severity "in the past 5 hours" on a 5-point Likert scale from 1 (*not at all*) to 5 (*extremely*). Items were selected based on the empirically-supported four-factor model of PTSD symptoms (i.e., intrusions, avoidance, numbing, and hyperarousal; King et al., 1998; Armour et al., 2016), with two items per dimension. The specific items were selected based on factor analytic results in each PTSD symptom dimension as well as careful attention to balancing reliability and validity to avoid the "attenuation paradox" (Loevinger, 1954; Tucker, 1946). Using the equations provided by Mehl & Conner (2012), reliability for this abbreviated EMA PCL-5 was calculated within a multilevel framework, showing within-person reliability (i.e., reliability of change) of $R_C = .78$ and between-person reliability of $R_{KF} = .99$.

Daily stress. Two measures were used in the EMA to assess levels of stress on a daily basis: self-report perceived stress and the number of daily stressors (counts). Perceived stress was assessed three times per day concurrently with PTSD symptoms by asking participants a single question: "How stressed you felt in general?" "in the past 5 hours", with responses on a 5-point Likert scale from 1 (*no stress*) to 5 (*very severe*). The second assessment was meant to be less subjective and so included a stressor checklist completed during the evening EMA. Specifically, participants were presented with the prompt: "Below is a list of troublesome things. Check ones that happened to you today." The list that followed included family demands or arguments, caring for a sick family member, tension with a spouse, tension with others, financial problems, transportation problems, home-related work, job-related work, and "other" stressors. Participants responded to the question by checking one or more stressors that occurred to them on a given day. A count of the total number of stressors experienced by each participant on a given day was used in subsequent analyses.

1.4. Analytic plan

Prior to analyses, data were inspected for missingness. The very first survey in the EMA period was deleted for all the participants (typically an evening survey after being trained on EMA) to avoid inconsistencies and to avoid practice effects as participants adjusted to completing the surveys. One participant had more than 50% of the momentary assessments data missing and was removed, leaving a final sample of 201 participants for primary analyses.

For each survey, a symptom severity score was calculated for each PTSD symptom dimension (i.e., intrusions, avoidance, numbing, and hyperarousal) by summing the corresponding EMA PCL-5 items. Daily mean scores were then calculated by averaging the corresponding severity scores across the three assessments on a given day and were used in the final analyses. A daily average was used rather than individual assessment throughout the day to increase reliability but also because the stressor count checklist was only surveyed at the end of the day. With the exception of daily number of stressors from the checklist, all study variables, including all the predictors and outcome variables, were grand mean standardized (to have a mean of zero and standard deviation of one) prior to running analyses. The daily stressors variable was not standardized because it was a count variable and standardization would alter the interpretation.

Primary analyses involved longitudinal two-level multilevel modeling (MLM), with Level 1 being the within-person level (i.e., daily) and Level 2 being the between-person level. The MLM analyses were conducted using the PROC GLIMMIX procedure in SAS, which by default uses restricted maximum likelihood estimation method. All models were estimated with random effects in the intercept and the slope (i.e., intercept and slope were allowed to vary at Level 2) and included estimation of a spatial power covariance structure (Bolger and Laurenceau, 2013). Prior to testing hypotheses, an unconditional model was estimated for each PTSD symptom dimension independently and an intraclass coefficient (ICC) calculated and reported for each symptom dimension.

To test for cascade effects, the effects of a given symptom dimension on day T were used to predict next-day's ($T+1$) other dimension (entered as a Level 1 predictor in the MLM). For example, intrusions on day T was used to predict next-day's ($T+1$) hyperarousal. This was repeated for all pairs of dimensions, as well as total daily PTSD symptom score. Models were run separately for each dimension to avoid distortion of effect estimates from high levels of multicollinearity. Moreover, in these models, it is not necessary to lag the outcome and include it as a predictor since this information is already captured by the MLM intercepts. Finally, similar models were run with stress as the predictor rather than a given symptom dimension to provide a point of comparison with regard to the effect sizes (self-perceived stress and stressor count were run as separate models, again due to multicollinearity).

2. Results

Descriptive statistics for PTSD symptom dimensions and ICC for each unconditional model are summarized in Table 2. On average,

Table 2
Descriptive Statistics for PTSD Symptom Dimensions in EMA.

Symptom dimensions[a]	*M*	*SD*	Zero-order correlations				ICC
			1	2	3	4	
1. Intrusions	2.94	1.20	1.00				.68
2. Avoidance	3.42	1.78	.74***	1.00			.79
3. Numbing	2.98	1.37	.83***	.70***	1.00		.81
4. Hyperarousal	3.51	1.81	.68***	.71***	.65***	1.00	.87

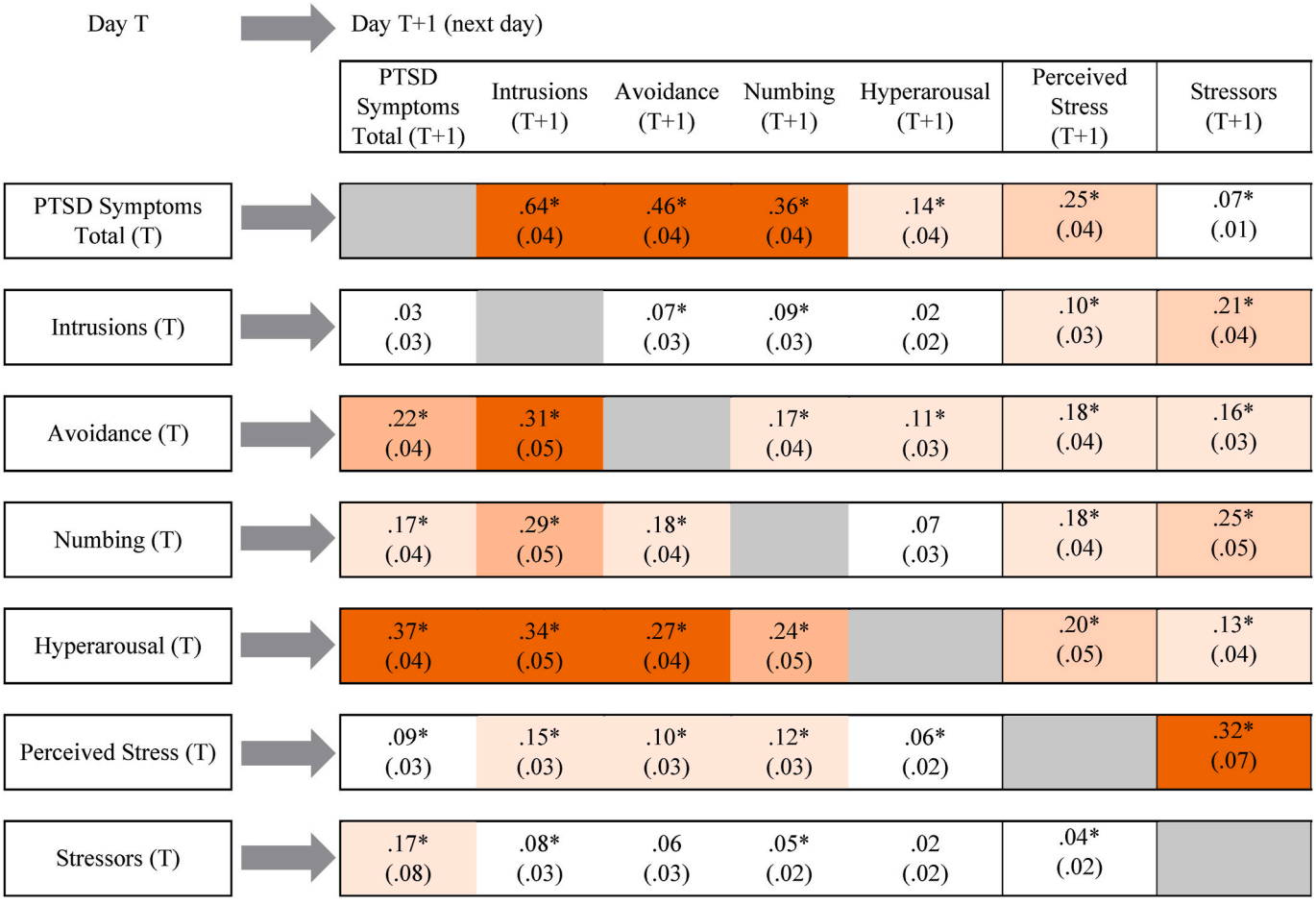
Note. $N = 201$. EMA = Ecological momentary assessment; PTSD = Posttraumatic Stress Disorder; ICC = Intraclass correlation.
***$p < .001$.
[a] The mean and SD reported here were calculated by first calculating an intraindividual mean of a given symptom severity (e.g., intrusions) across seven days for each participant, and then calculating the descriptive statistics (e.g., *M*, *SD*) of these intraindividual means.

hyperarousal and avoidance were the most endorsed symptom types across the week ($M > 3.40$). ICC's indicated that variability in daily PTSD symptoms was largely driven by between-person differences rather than within-person changes across the week (especially for hyperarousal, numbing and avoidance). Still, all four dimensions had significant, daily within-person variability across the week.

Fig. 1 summarizes the MLM mean parameter estimates from a given day's PTSD symptom dimensions and stress on next-day overall PTSD symptoms as well as each PTSD dimension. For sake of presentation, all parameters are listed together in Fig. 1, but the MLM models were run separately for each predictor as described above.

As seen in Fig. 1, hyperarousal was by far the strongest predictor of next-day overall PTSD symptoms ($\beta = .37$, $p < .001$), as well as next-day intrusions, avoidance, and numbing (β's = .34, 0.27, and 0.24, respectively, p's < 0.001). These effects were far larger than what was seen for other variables, for example often more than double the effects from self-perceived stress.

In contrast, intrusions was not a significant predictor of a next-day symptom cascade, but instead was most susceptible to the effects of other dimensions, indicating it was rarely the leading edge of a cascade. Specifically, next-day intrusions was significantly predicted by all other variables, with the strongest effects from day-before total PTSD symptoms, hyperarousal and avoidance (β's = .64, 0.34, and 0.31,



Notes. Numbers represent within-person multilevel model standardized beta coefficients (SD in parentheses). Darkest shade for betas > .30, next darkest for .20 - .29, lightest for .10 -. 19, and no shade for beta's < .10. Models were run separately for each row and column. PTSD = Posttraumatic stress disorder. * $p < .05$.

Fig. 1. Heatmap of effects between overall PTSD symptoms, intrusions, avoidance, numbing, hyperarousal, or stress on one day (T) to those same variables on the next day (T+1).
Notes. Numbers represent within-person multilevel model standardized beta coefficients (SD in parentheses). Darkest shade for betas > 0.30, next darkest for 0.20 - 0.29, lightest for 0.10 -. 19, and no shade for beta's < 0.10. Models were run separately for each row and column. PTSD = Posttraumatic stress disorder. *$p < .05$. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

respectively, p's < 0.001).

Avoidance and numbing had an intermediate pattern, both predicting other next-day dimension changes, but also being susceptible to effects from other dimensions. Effect sizes for these bidirectional effects were less pronounced than those of hyperarousal but greater than those associated with intrusions.

Effects of stress on symptoms was also estimated and reported in Fig. 1. As seen there, perceived stress was a significant predictor of next-day total PTSD symptoms ($\beta = .09$, $p < .001$), with strongest effects for prediction of next day intrusions ($\beta = .15$, $p < .001$) and weakest for prediction of next day hyperarousal ($\beta = .06$, $p < .001$). A similar pattern was evident for stressor count. Interestingly, stress markers were as susceptible to the effects of symptoms as the reverse if not more in some cases, underscoring cascades are not simply byproduct of stress, but integral parts of the phenomenon. To this end, effect sizes (standardized betas) observed for effects from self-perceived stress on symptoms were far lower than the effect sizes from symptom dimensions predicting one another or overall PTSD symptoms from one day to the next.

3. Discussion

The present study investigated potential PTSD symptom cascades in daily life. Results from a sample of responders to the WTC disaster indicated that the occurrence of certain PTSD symptoms on a given day forecasted spikes in other symptoms of the disorder on the following day. Most notably, increased hyperarousal on a given day was the strongest prospective predictor of overall PTSD symptoms as well as each of the other PTSD symptom dimensions on the next day. Effects from hyperarousal were almost double that of other symptom dimensions as well as more potent than predictions based on daily stress or stressors per se. Intrusions, in marked contrast to hyperarousal, trailed the occurrence of other symptoms rather than led them. Specifically, every elevated PTSD dimension as well as stress predicted elevated intrusion symptoms the next day, but the reverse effects were much weaker. Finally, avoidance and numbing dimensions had a similar temporal profile as hyperarousal, but their effects were less pronounced.

Study results are critical because identification of temporal symptom interplay is an important first step to establishing which PTSD symptom dimensions play a key role in disorder maintenance/chronicity. Despite the promise of identifying such dynamics, the interpretation of patterns we observed must be made with caution given that the present study relied on observational and self-report data. Symptoms of hyperarousal could be directly triggering other symptoms in line with the cascade hypothesis, but they could instead be interacting with unobserved mechanisms (e.g., affective or cognitive processes) that instead are the trigger for the cascade. Alternatively, findings may be incidental to unobserved underlying processes related to symptom maintenance.

Despite this caution, previous work on PTSD lends credence to the central role of hyperarousal in maintenance of symptoms. Autonomic nervous system dysfunction is among the most replicated findings in PTSD (Pitman et al., 2012). To the degree that hyperarousal symptoms most closely reflect such dysfunctions, the present study suggests underlying autonomic nervous system vulnerabilities might constitute a maintenance factor for other symptoms of PTSD in daily life. This is in contrast to more cognitive (e.g., intrusive memories), behavioral (e.g. avoidance) or affective (i.e., numbing) aspects of the disorder, that tended to be more reactive to hyperarousal symptoms rather than to forecast them. This suggests that interventions focused directly on treating hyperarousal, or the underlying mechanisms related to hyperarousal symptoms, might be most effective in reducing symptom cascades in WTC responders and possibly other traumatized populations.

Results also highlight the intriguing possibility that hyperarousal symptoms represent the most potent target for EMIs. A number of such interventions have been proposed for PTSD (e.g., PTSD Coach app; Owen et al., 2015), but none are strategically focused on a subset of symptoms, nor do any seek to halt cascades in the moment. The present study opens the possibility that targeted EMIs, to the degree they are designed to be effective in the moment and focus on specific symptom dimensions, may have the most potential to disrupt or halt symptoms cascades and a fuller expression of the disorder in the short-term.

Beyond symptom dimensions per se, the present study is among the first to estimate the impact of daily stress and stressors on daily PTSD symptom expression. Effects were less pronounced than those observed for symptom dimensions, but were nevertheless detectable and represent another avenue for novel, ecologically-based interventions. However, the impact of such a focus may be limited. Stress tended to most impact intrusion symptoms of the disorder, which in and of themselves were not strong predictors of an overall symptom cascade. Findings also highlighted how perceptions of stress may also be vulnerable to effects from symptoms, suggesting this may represent an additional pathway for full expression of symptoms.

Beyond identifying temporal dynamics among symptom dimensions, the present work underscores the value of investigating the multiple dimensions of PTSD, rather than conceptualizing the disorder as a unitary syndrome. This is consistent with past work in the World Trade Center population indicating that only some types of PTSD dimensions were associated with dysfunction and exposure severity (Ruggero et al., 2013). Additionally, results are consistent with factor-analytical research indicating multiple (compared to one) symptom dimensions for PTSD (Armour et al., 2016) as well as theoretical conceptualizations of how these PTSD symptom dimensions are functionally related to each other (Brewin and Holmes, 2003).

Despite the implications of the present results, a number of limitations need to be considered. First, hyperarousal demonstrated the lowest within-person variability, as reflected by its high ICC, whereas intrusions reflected the highest within-person variability, as reflected by its lowest ICC. Thus, the effects of hyperarousal could be driven in part by the difference in temporal stability of symptom dimensions. However, differences in multilevel model effects were magnitudes larger than differences in the ICC values, suggesting that this alone cannot explain the results. Second, most of this sample consisted of men and those whose PTSD symptoms persisted 15 years after trauma. Processes among women, or in those closer in time to the traumatic event, may be different. Third, symptoms may be having complex interactions with external events, such as reminders of the trauma in the environment, which were not assessed in the current study. Therefore, we cannot know from the present work whether and how these contribute to symptom cascades, or whether symptoms reflect simply proxies for other events. This concern is somewhat mitigated by our findings that triggering effects between symptoms are substantially stronger than effects of stressors on symptoms.

Despite these limitations, the present work represents an important demonstration of the potential for PTSD symptom cascades in daily life. Some symptoms dimensions, notably hyperarousal, play an outsized role in forecasting other PTSD symptoms in the short-term, whereas others, such as intrusions, tend to trail in their expression. Whether symptoms of hyperarousal directly provoke other symptoms, or merely reflect the occurrence of processes not measured in this study, remains to be established. Nevertheless, this study sheds light on a potentially important mechanism in the process of PTSD symptom maintenance. Its insights can inform novel EMI's aimed at disrupting cascades and potentially facilitating remission.

Contributors

All authors contributed to the conception and drafting of the manuscript.

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Declaration of competing interest

All authors declare that they have no conflicts of interest, financial or otherwise.

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