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Context and Craving During Stressful Events in the Daily Lives of Drug-dependent Patients

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Abstract

Rationale—Knowing how stress manifests in the lives of people with substance-use disorders could help inform mobile “just in time” treatment.

Objectives—To examine discrete episodes of stress, as distinct from the fluctuations in background stress assessed in most EMA studies.

Methods—For up to 16 weeks, outpatients on opioid-agonist treatment carried smartphones on which they initiated an entry whenever they experienced a stressful event (SE) and when randomly prompted (RP) three times daily. Participants reported the severity of stress and craving and the context of the report (location, activities, companions). Decomposition of covariance was used to separate within-person from between-person effects; r_{effect} sizes below are within-person.

Results—Participants (158 of 182; 87%) made 1,787 stress-event entries. Craving for opioids increased with stress severity ($r_{\text{effect}} = 0.50$). Stress events tended to occur in social company (with acquaintances, 0.63, friends, 0.17, or on the phone, 0.41) rather than with family (spouse, -0.14 ; child, -0.18), and in places with more overall activity (bars, 0.32; outside, 0.28; walking, 0.28) and more likelihood of unexpected experiences (with strangers, 0.17). Being on the internet was slightly protective (-0.22). Our prior finding that being at the workplace protects against background stress in our participants was partly supported in these stressful-event data.

Conclusions—The contexts of specific stressful events differ from those we have seen in prior studies of ongoing background stress. However, both are associated with drug craving.

Keywords

cocaine; heroin; ecological momentary assessment; stress; craving

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The commonly held assumption that stress plays a causal role in addiction and relapse has been given biological plausibility by consistent findings of overlap in the neural circuitry affected by stress and drug use (Cleck and Blendy 2008) and by lab-animal studies showing that acute stressors such as footshock increase the likelihood of drug-seeking behavior (Bossert et al. 2013; Cleck and Blendy 2008). In humans with addiction, stress responses in a laboratory predict susceptibility to relapse (Sinha et al. 2006).

The idea of stress-induced relapse has led to treatments intended to mitigate the effects of stress. For example, laboratory studies showing that alpha-2 adrenergic agonists decrease stress-induced reinstatement of drug seeking in rats (Erb et al. 2000; Highfield et al. 2001) and stress-induced drug craving in humans (Fox et al. 2012; Jobes et al. 2011) led our research clinic to conduct a randomized clinical trial that found that clonidine increased time to lapse and longest duration of abstinence during treatment for heroin addiction (Kowalczyk et al. 2015). Most evidence-based psychosocial treatments for addiction, such as cognitive-behavioral therapy (Carroll 1998) and Acceptance and Commitment Therapy (ACT) (Hayes et al. 2013)(Brewer et al. 2009; Chiesa and Serretti 2014; Hoppes 2006; Luoma et al. 2012), incorporate the teaching of techniques for responding adaptively to stress.

These kinds of treatments, which have until now been administered only in a clinician's office during scheduled visits, or sometimes by desktop computer (Carroll et al. 2014) are becoming mobile— adapted for delivery when and where they are needed (Lindhiem et al. 2015; Nahum-Shani et al. 2016). Our knowledge base has not caught up to this change (Hekler et al. 2016; Riley et al. 2011). Much of what we know about addiction and stress is based on retrospective studies in which weeks or months intervene between the event and its recollection, leaving ample time for recall bias or the formation of *post hoc* explanations for behavior. These problems are now being surmounted by Ecological Momentary Assessment (EMA) (Shiffman et al. 2008), in which people report their moods and behaviors in real time on mobile devices. The EMA data we collected during our clonidine trial (Kowalczyk et al. 2015) provided mechanistic insight we could not otherwise have had, showing that clonidine seemed to act by decoupling stress from craving.

In our clonidine trial, we assessed only changes in “background” levels of stress—meaning levels of stress as a tonic state, rated in randomly prompted reports throughout the day. This is how stress was assessed in all published EMA studies we know of, until our group began to incorporate assessment of participant-defined episodes of stress. We ask participants to initiate an EMA report of every stressful event they undergo, as soon as it happens, while we continue to assess levels of background stress in randomly prompted reports (Furnari et al. 2015). This helps ensure that we do not miss the instances of peak stress. In this paper, we use those data to examine patterns of stressful events in the lives of people with opioid-use disorders during up to 16 weeks of agonist maintenance. Their data enabled us to examine drug craving in the context of discrete episodes of stress as well as fluctuations in randomly assessed background stress.

Patients and Methods

Participants

The participants were methadone- or buprenorphine-treated opioid-dependent patients at a treatment-research clinic in Baltimore, MD. All were participating in a 46-week natural-history study of stress, geographical location, and drug use. Our prior publications of data from a subset of participants in this study focused primarily on ambulatory physiological monitoring (Hossain et al. 2014; Kennedy et al. 2015; Rahman et al. 2014) and an examination of the relationship between stress and drug use (Furnari et al. 2015).

During screening, participants completed the Addiction Severity Index (ASI; McLellan et al. 1985) and the Diagnostic Interview Schedule (DIS IV; Robins et al. 1995) and were given physical examinations and psychological testing. The main inclusion criteria were: age 18 to 75 years, physical dependence on opioids, and (due to the behavioral-geography focus of the parent study) residence in Baltimore City or one of the surrounding counties. The main exclusion criteria were: history of any DSM-IV psychotic disorder, bipolar disorder, or current Major Depressive Disorder; current dependence on alcohol or sedative-hypnotics; cognitive impairment precluding informed consent or valid self-report; conditions that preclude urine collection; or medical illness or medications that would compromise research participation. This study was reviewed and approved by the National Institutes of Health Addictions Institutional Review Board. Participants gave prior written informed consent and were paid for completing the research components of this study.

Procedure

Participants attended clinic five to seven days a week; methadone or buprenorphine was administered daily, and individual counseling was given weekly. Urine was collected under observation and screened for illicit drugs thrice weekly. Urine was tested for the presence of heroin and other opioids (through testing for morphine), oxycodone (through a more specific assay), buprenorphine, cocaine metabolite, amphetamines, and cannabinoids.

After two weeks of treatment, each participant was trained to use a smartphone as an electronic diary and then carried it for up to 16 weeks, during weeks 3–18 of the study. The smartphones were programmed with our electronic-diary software (Vahabzadeh et al. 2004; Vahabzadeh et al. 2012) to prompt participants three times per day to answer a series of questions. The timing of the prompts was random, but constrained by the individual participant's self-reported typical waking hours for each day of the week. Participants also initiated entries whenever they experienced a stressful event (SE).

For the stress-event entries, we asked participants to initiate an entry any time they felt “more stressed, overwhelmed, or anxious than usual” and to check whichever applied when they initiated an entry (multiple responses were possible). To categorize severity of each stress event, participants were asked to designate as a “hassle,” “something that could spoil the day,” or “something that could do more than spoil the day,” and to rate “how bad was that feeling” on a 0–10 scale. They indicated the cause of the feeling by selecting from a list: conflict with someone; had too much to do; problems with money; surroundings were unsafe or threatening; was inconvenienced; injury or health problem; legal problem; just started

thinking about stressful things; or “other” (a “fill in the blank” option). In each of these SE entries, participants rated how much they craved opioids and cocaine, and reported whom they were with, what they were doing, and where they were, from dropdown lists. The list of questions from the stress event entries is shown in Table 1.

Participants also initiated an EMA entry any time they used a drug for nonmedical purposes, and completed an end-of-day questionnaire before bed. Data from these entries are not reported here.

In random-prompt (RP) entries, participants rated their stress level and how much they craved opioids and cocaine and indicated whom they were with, what they were doing, and their location from dropdown lists. (Participants were also asked to rate their mood using a list of 28 adjectives and to report whether they had recently seen, been offered, or seen others using drugs, alcohol, or tobacco; data from these measures are not reported here.) The participants were paid \$10 each week for completing at least 82% of their random prompts, or were given a warning if they did not meet the criterion. Participants who did not meet the 82% completion criterion for 2 weeks after being warned were removed from the study and assisted with transfer into community-based addiction treatment.

Data Analysis

We tested associations among variables using either general or generalized linear mixed models.

Specifically, we used general linear mixed models (SAS Proc Mixed) when the dependent variables were numerical ratings of craving and stress. The predictors in these models were: categories of stress, such as “anxious” versus “overwhelmed”; categories of stress severity, such as “hassle”; and numerical ratings of stress severity (as a predictor of numerical ratings of craving).

We used generalized linear mixed models (SAS Proc Glimmix) when the dependent variables were dichotomous measures. This was the case for most of our analyses, in which we were testing whether stress-event entries were disproportionately associated with particular contexts. Although causation would almost certainly be bidirectional, the models required that we designate predictors and dependent variables. The predictor in each model was a possible context (e.g., being with friends vs. not being with friends), and the dichotomous dependent variable was the type of EMA entry (stress-event entry versus randomly prompted entry). Thus, these models tested whether stress events were over- or underrepresented in a given context relative to random-prompt entries, a proxy for the amount of monitored time spent in that context.

In all the mixed models, we used a spatial-power error structure, which accounts for within-person correlations as a function of the interval between successive entries. Denominator degrees of freedom were conservatively set to reflect the number of participants rather than the number of measurement occasions, as recommended by Bolger and Laurenceau (2013). The predictors were treated as fixed, but each model used a random intercept. Alpha was set at .05, two-tailed, for all analyses. To adjust for the familywise error rate in multiple tests of

significance when we compared contexts of stress-event and random-prompt entries, we entered all obtained p values into the SAS procedure Multtest to obtain false-discovery-rate (FDR) p values, which are the ones we report.

Where appropriate, we used F values to calculate effect-size r values (r_{effect} values) as specified by Rosnow et al. (2000), with associated 95% confidence intervals. The Rosnow et al. (2000) procedure for calculating r_{effect} values has not been formally tested in the context of intensive longitudinal data and is dependent on the method used to specify denominator degrees of freedom. Therefore, our reported r_{effect} values should be interpreted with caution in terms of cross-study comparisons (e.g., eventual inclusion in meta-analyses), but are useful for comparisons of effects within our results.

We also checked whether the relationships we found were artifacts of between-person differences rather than within-person associations. Mixed models can account for this problem when participants differ widely on the outcome variable, but do not automatically account for it when people differ widely on the predictor (van de Pol and Wright 2009). Where possible, we checked for this with a model-based method (van de Pol and Wright 2009) in which momentary values are centered on person-level means; for those models, we treated dichotomous predictors (0,1) as numeric variables so person-level “means” could be calculated. When we had no model-based method appropriate for separation of within-person from between-person effects, we checked by descriptively examining how many participants showed patterns of results consistent with the overall pattern (Branch 2014).

Results

Participants and EMA reporting and compliance

Data were collected between July 14, 2009 and June 4, 2015. Of 226 individuals who signed consent, 182 provided EMA data for at least two weeks, 12 provided EMA data for less than two weeks, and 32 left the study before providing any EMA data. Of the 182 participants who provided EMA data, 158 participants (87%) reported at least one stress-event entry, for a total 1,787 stress-event entries. The demographic and drug-use histories of all 182 participants who provided EMA data and the 158 who made stress-event entries were similar (Table 2).

Overall, the participants provided EMA data for a mean ($\pm$ SD) of 101.0 ($\pm$ 26.6) days (range 14–156) over 18,379 study days. On average, they completed 2.4 ($\pm$ 0.4) random-prompt entries per day, for a total of 44,724 entries, with an overall compliance rate of 81%. The 158 participants who made at least one stress-event entry provided EMA data for a mean ($\pm$ SD) of 102.2 ($\pm$ 25.5) days (range 14–156) over 16,152 study days and completed 2.4 ($\pm$ 0.4) random-prompt entries per day for total of 38,768 entries, with an overall compliance rate of 80%.

Stress events

Adjectives (stressed, overwhelmed, anxious) were missing for 47 of the 1,787 stress entries due to a technical error. Of the remaining 1,740 entries, 46.0% were stressed only, 20.0% anxious only, 19.9% overwhelmed only, and 14.0% were assigned more than one adjective

(8.7% stressed and overwhelmed, 1.7% stressed and anxious, 0.2% overwhelmed and anxious, and 3.4% all three). In a mixed regression, mean stress ratings differed significantly across the four categories (in ascending order: anxious, $3.89 \pm .21$; stressed, $4.46 \pm .18$; overwhelmed, $4.74 \pm .21$; multiple adjectives, $5.80 \pm .25$), $F(3,208) = 22.95$, $p < .0001$). In Tukey pairwise comparisons, each of those four means was different from each of the others, except “stressed” versus “overwhelmed.” Additional models for decomposition of covariance showed that these adjective/severity relationships were present both within and between participants (r_{effect} sizes for the various pairwise comparisons were 0.28 to 0.58 within participants, 0.06 to 0.36 between participants, $r_{\text{effects}} > 0.16$ were statistically significant).

Across all stress-event entries, the participants’ mean (SEM) rating of “how bad” the stress event felt was 5.04 (0.07) on a 0–10 scale. Categorical descriptions of severity were: 45.4% “hassle,” 30.3% “something that could spoil the day,” and 24.4% “something that could do more than spoil the day.” Across those three categories, there was a linear increase in mean ratings of “how bad” the event felt (0–10 scale), $F(1,193) = 99.77$, $p < .0001$, $r_{\text{effect}} = .58$ (CL95 .47, .67) (Figure 1a). An additional model for decomposition of covariance showed that this relationship was present both within and between participants (r_{effect} size 0.80 within, 0.51 between). Even so, when we examined the raw data person by person (Branch 2014), we found that the relationship was not perfect: of the 118 pts who used more than one categorical label for severity across occasions, only 49% gave numerical ratings that increased as would be expected with severity category, for 39%, numerical ratings were flat or fluctuated across categories, and for 12%, numerical ratings actually decreased across categories (see Discussion).

Participants were asked to choose the source of the stressful event from a dropdown list with an “other” option. The sources, in decreasing order of frequency, were: interpersonal conflict, just thinking about stressful things, money problems, having too much to do, being inconvenienced, “other,” injury or health problems, legal problems, and unsafe surroundings (Figure 1b). Across sources of stress, ratings of “how bad” varied without a clear relationship to frequency (Figure 1b). The “other” events made up 11% of the entries and had the numerically highest mean severity rating. We classified the “other” events into seven categories: issues related to family or significant others (3.0%), general problems (2.9%), study-related issues (1.5%), anticipation of positive events (0.6%), death of or violence toward a family member or friend (0.6%), concerns about drug use or maintaining abstinence (0.5%), and indeterminate (1.6%).

Craving in stress-event entries

Across levels of acute stress (rated 0–10) in stressful events (Figure 2), there were linear increases in both opioid craving ($b = 0.13 \pm 0.02$, CL95 0.10, 0.16, $F[1,156] = 63.78$, $p < .0001$) and cocaine craving ($b = 0.03 \pm 0.01$, CL95 0.005, 0.05, $F[1,156] = 5.62$, $p = .019$). Additional models for decomposition of covariance showed that the relationship between stress severity and heroin craving was present both within and between participants ($r_{\text{effect}} = 0.50$ within, 0.26 between). For cocaine craving, however, the relationship with stress was

accounted for mostly by between-participant differences ($r_{\text{effect}} = 0.14$ within, 0.22 between; $r_{\text{effects}} < 0.16$ were not statistically significant).

Context of stress-event entries vs. background (RP) entries

Figure 3 shows raw data (i.e., data across all EMA entries, ignoring person-level differences) for the contexts (companions, location, activities) of the stress-event entries and RP entries. The figure does not show categories reported in fewer than 3% of entries and not differing between stress and RP entries; thus, not included are three locations (abandoned building, church, shelter) and seven activities (child/elder care, sports or recreation, buying drugs, illegal activities, hustling for money, reading, twelve-step activities). The figure is intended to illustrate the overall prevalence of each context. In our generalized linear mixed models, we analyzed the data the other way around, with each context as the predictor and the entry type (stress event versus RP) as the outcome—a choice reflecting our view that causation, though likely bidirectional, may flow more from context to mental state than vice versa. The analyses could be operationalized either way with similar results. (Our use of the terms *risk factor* and *protective factor* is purely statistical.) Results of the analyses are in Table 3.

As shown in Table 3, the companion types most strongly associated with stress events were acquaintances (this was one of the strongest associations in the dataset) and coworkers, along with “out the gate” partners (companions who help acquire a morning dose of drug), strangers, and friends. Being alone or being with a child were each associated with a lower probability of stress. All these associations were stronger at the within-person level than the between-person level. Being with a spouse/partner or other family member was, if anything, slightly protective against stress, but not to a statistically significant degree. Being with clinic staff or patients was not associated with stress.

The locations most strongly associated with stress events were bars/clubs and outdoor locations. Home, and others’ homes, tended to be protective against stress (Table 3). The workplace was, if anything, a slightly protective location (though this was not statistically significant), even though being in the company of coworkers was associated with stress. Almost all these associations were stronger at the within-person level than the between-person level.

The activity most clearly associated with stress was arguing—this was the strongest contextual association in the dataset (Table 3). Outdoor and social activities were also associated with stress, as were “other” activities, which, based on fill-in responses, included family conflicts, family and personal health crises, and courtroom situations. Stress events were less likely when participants were resting, watching TV, eating, or on the internet. All these associations were stronger at the within-person level than the between-person level. Stress events were not differentially associated with any of the other activities we assessed, though shopping/errands, thinking, and coping (buying drugs) appeared marginally likely to be risk factors. Working, as an activity, showed no sign of an association with stress.

Discussion

The primary purpose of this paper is to present a detailed first description of the overall patterns of stressful events reported by individuals with opioid use disorders during treatment. Because of the way we asked participants to report every stressful event as it happened, this is the first data set of its kind.

We asked participants to assign a numerical severity rating to each stressor on a 0–10 scale, but, anticipating that the results might be hard to interpret, we also asked them to rank the severity of each stressor in everyday language—as “a hassle,” “something that could spoil the day,” or “something that could do more than spoil the day.” The usefulness of this classification was borne out by comparison of the two sets of responses. The relationship was strong overall, but in more than half of the participants, it was not entirely orderly and was sometimes even contradictory. We take this to mean that a 0–10 scale without verbal anchor points, used repeatedly without access to one’s own prior responses on it, can lead to inconsistencies across measurement occasions. Accompanying such a scale with an everyday-language item (or incorporating everyday-language anchors into the scale) seems likely to produce results that more straightforwardly capture a respondent’s experiences across time.

The severity of stressful events in our participants was associated with greater craving for drugs. This finding is consistent with our earlier work on background stress in a similar cohort of patients in opioid agonist treatment (Kowalczyk et al. 2015; Preston and Epstein 2011). The detection of craving at the time of stressful events is not surprising, but is important because craving is a key feature of addiction: it predicts treatment outcome (Higley et al. 2011; Tsui et al. 2014) and has been added as a criterion for diagnosis of substance-use disorders in DSM-5 (Murphy et al. 2014). This study confirmed prior studies showing that craving increases with stress when recorded at random times and suggests that the craving may be even higher at the time of a specific stressful event compared to background stress. The relationship was stronger for heroin craving than for cocaine craving; this difference had been present to a lesser degree in our earlier work with background stress (Preston and Epstein 2011).

One difference between these and our earlier EMA findings concerns stress in the workplace. In our earlier study we found that background stress was lower at the workplace than at any other location, and that mood was better in the presence of coworkers than with other companions (Epstein and Preston 2012)—a finding we took to mean that the workplace, for our population, can be a respite from chaotic home environments (Damaske et al. 2016). In the current analyses of stressful events, not so. Being in the workplace appeared somewhat protective (though this did not reach statistical significance); being with coworkers was clearly associated with an increased likelihood of stressful events; the activity of working had no association with the likelihood of stressful events. Being at home was strongly protective. This discrepancy probably reflects the difference between fluctuations in mental state versus occurrence of specific external stressors. Arguably, neither should go unassessed (Deutsch 1986).

The “external event”-driven nature of our data is underscored by the other situational correlates of stress-event entries: they tended to occur in social company (with acquaintances or friends, or on the phone) rather than with family (spouse/partner, child), and they tended to occur in places where there is more overall activity (bars/clubs, outside hanging out, walking) and more likelihood of unexpected experiences (in the presence of strangers). These are the kinds of environmental exposures we are trying to quantify with our ongoing studies of activity space using GPS (Epstein et al. 2014). A more nuanced picture of what happens at home, with spouses and other partners or family members, could emerge from dyadic EMA, in which both members of a relationship or household respond independently to the same mobile assessments (Dunton et al. 2016; Laurenceau and Bolger 2012). The robust association of stress events with the presence of “out the gate” partners (drug-acquisition companions) may partly reflect the fact that, as shown in laboratory studies, drug cues may be stressors in people who are trying to abstain (Sinha et al. 2006; Sinha et al. 2003).

The absence of any overall protective effect of listening to music might be an artifact of the relative crudeness of the item we used. An EMA study that focused on music listening (in a general-population sample) showed that music reduces stress only in social situations or when listened to alone for the specific purpose of stress reduction (Linnemann et al. 2016).

The slightly stress-protective effect of internet use contrasts with studies that have shown deleterious long-term effects of overuse of social media (Sriwilai and Charoensukmongkol 2016; Zheng and Lee 2016). However, the association in our data was at the momentary level: it can be summarized as “during internet use, there were fewer stressors” rather than “for people with more overall internet use, there were fewer stressors.” This is consistent with findings that social-media use can buffer acute stress (Rus and Tiemensma 2016).

When we asked participants to give reasons for stress events, the most frequent responses included busyness and interpersonal conflicts, both in keeping with the event-driven nature of the data. Participants also frequently cited money problems; this accords with the unsurprising prior finding, in healthy volunteers, that having at least sustenance-level cash available is an independent predictor of life satisfaction (Ruberton et al. 2016). It also accords with prior findings that financial stress can be a major barrier to recovery from addiction (Siahpush et al. 2009). Distinct from the other types of stress events was the high frequency of reports brought on by having “just started thinking about stressful things.” These can be taken as instances of ruminative stress, which may be especially deleterious to emotional health (Snyder and Hankin 2016) and is specifically associated with craving (Caselli et al. 2010; Caselli et al. 2013). In future studies we plan to analyze stress responses as a function of trait differences such as proneness to anxiety. One of the more rare causes of stress events was the feeling that one’s surroundings were unsafe—but when that did occur, it led to some of the highest ratings of stress severity. This finding supports the importance of studying and trying to address environmental precipitants of stress and drug seeking.

A limitation of this study is that we cannot know how many stress events went unreported. When we tested the EMA program ourselves to check that it was working properly, we found that at the peak of a stressful event, we did not always have time to make an entry.

This is likely to have been the case for our study participants as well. Nevertheless, most participants (87%) made at least one stress entry, and there were no discernible differences between those who did and those who did not, an area we intend to explore in future analyses. The methods appear to have worked insofar as the data are internally consistent. Stress ratings increased with other measures of severity, and associated responses, such as being with a coworker at work while working, had effects in the same direction, even if not always meeting statistical significance.

In hindsight, one thing we would have done differently to reduce burden and increase data quality would be to let participants add a few of their own categories to our dropdown list of stress causes. Addition of biosensors to detect physiological signs of stress, a technique we have started to explore (Kennedy et al. 2015; Sarker et al. 2016), could both validate the stress events and indicate the circumstances under which participants fail to report stressful events. Finally, programming the electronic diary to deliver timed follow-up questions could provide information on the duration of each stress episode, the extent of consequent craving, and the occurrence of associated drug use. We analyzed some of those stress/drug associations in more detail in a prior publication (Furnari et al. 2015); this paper complements that one by providing an overview of the stress events themselves.

The kind of description presented here is a necessary step toward developing an intervention (Sidman 1960). There is already evidence, in healthy adults, that a mobile, automated “just in time” intervention (JITI) for a stress event can buffer the effects of the next day’s stressors (Donald et al. 2016). Next steps from our current findings to a stress-targeted JITI for addiction should include situation- and person-specific analyses (Russell and Odgers 2016) so that the intervention can be matched to the event.

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Fig. 1.

Severity and causes of stressful events. a. Bars show percentages of stressful events categorized by participants as “a hassle,” “something that could spoil the day,” or “something that could do more than spoil the day.” Filled circles show mean numerical rating of stress severity for each severity category. b. Bars show percentages of stressful events attributed to each of nine possible causes. Filled circles show mean numerical ratings of stress severity for each cause. Brackets indicate the standard error of the mean.

Fig. 2.

Drug-craving severity as a function of stress-event severity Craving was rated 1–5 scale (1 indicating no craving) for opioids and cocaine. Means and standard errors are from a mixed regression run solely to generate those estimates for display, treating the 0–10 stress rating as an 11-level categorical predictor rather than a continuous predictor.

Fig. 3.

Contexts of stress-event and random prompt entries. The bars show raw percentages of the entries in which each context occurred in the 158 participants who made any stress entries. Asterisks mark contexts that were differentially associated with stress in generalized linear mixed models (SAS Proc Glimmix), but note that in those models (Table 2), the predictor was the presence/absence of each context and the outcome was the proportion of each entry type (stress versus RP) in that context. Here we show the data in the opposite way (proportion of entries in each context, as a function of entry type) to give a clear view of the

prevalence of each context. The data are shown at the raw momentary level (i.e., as 38,768 RP entries and 1,740 stress-event entries) without regard to the person-level differences that are taken into account by the models in Table 2.

Table 1**EMA Stress-Event Questions**

Question	Response Options
How do you feel? (check all that apply)	stressed; overwhelmed; anxious
How bad is the feeling? *	0–10 (0 = not bad at all, 10 = the worst you've ever felt)
Was the feeling mostly because... (choose one)	you had a conflict with someone; you had too much to do; you had problems with money; your surroundings were unsafe or threatening; you were inconvenienced; you had an injury or health problem; you had a legal problem; you just started thinking about stressful things; other [fill in the blank]
How big a problem was this? (choose one)	a passing annoyance/hassle; something that could spoil the day; something that could do more than spoil the day
How well can you deal with the feeling right now?	1–5 (1 = not at all, 5 = extremely well)
Right now, do you crave heroin/other opiates (Percocet, oxycodone, etc.)? **	1–5 (1 = not at all, 5 = extremely)
Right now, do you crave cocaine? **	1–5 (1 = not at all, 5 = extremely)
Where were you when the use/stress started? (choose one) ***	home; work; vehicle (car, bus, train); waiting for ride, bus, etc.; another's home; abandoned/minimium/vacant home; outside hanging out; walking from one place to another; restaurant; store; church; shelter; bar/club; clinic/doctor; other [fill in the blank]
Who were you with when the stress started? (check all that apply) ***	no one; spouse / partner; child(ren); other family; coworkers friends; acquaintances; clinic staff / patients; strangers; out-the-gate partner
Were you with at least one person who you have ever used with? ****	Yes; No
Were you with at least one person who still uses? ****	Yes, No
What were you doing when the stress started? [check all that apply] ***	resting/sleeping; working; walking/riding/travelling; eating or preparing food; watching TV/ videos/ DVD; listening to music; talking on phone; talking/ socializing; arguing; household chores or personal hygiene; shopping/errands; child care / elder care; sports / games / other recreation; reading; thinking/ planning; waiting; coping; other illegal activities; legal hustling; on internet; other [fill in the blank]

* In the RP entries participants rated "How much stress are you feeling right now?" on a 1–5 (1 = not at all, 5 = extremely) scale.

** Wording of these questions in RP entries was "Within 5 minutes of the ED beeping / Since you got to your present location, did you crave..." and was rated on the same 1–5 scale.

*** Wording of these questions in RP entries was "Who are you with?" [check all that apply], "What were you doing when the beep occurred" [check all that apply], and "Where are you now?" (choose one). Response options for stress event and RP entries were identical.

**** Questions in RP entries were the same.

Table 2

Clinical and demographic characteristics

	All Participants	Participants with Stress Events
N	182	158
Opioid agonist treatment		
Methadone	107 (58.8%)	91 (57.6%)
Buprenorphine/naloxone	75 (41.2%)	67 (42.4%)
Sex		
males	135 (74.2%)	113 (71.5%)
Age mean (SD) years	41.9 (9.6)	42.4 (9.7)
Race		
African American	64.8%	64.6%
White	34.0%	32.9%
Education mean (SD) years	12.1 (1.5)	12.1 (1.6)
Marital Status		
Married	13.3%	14.6%
Never married	60.8%	59.9%
Separated/divorced/widowed	26.0%	25.5%
Employment Status		
Full Time	46.4%	44.0%
Part Time	22.6%	22.9%
Unemployed	25.4%	26.8%
Retired/disability/controlled	5.5%	6.4%
Drug Use History		
Days used in last 30		
Heroin mean (SD)	19.3 (11.9)	19.1 (11.9)
Other Opioid mean (SD)	8.1 (10.3)	8.0 (10.3)
Cocaine mean (SD)	4.5 (8.5)	4.6 (8.5)
Years Using		
Heroin mean (SD)	14.5 (10.2)	14.5 (10.5)
Other Opioid mean (SD)	1.4 (2.6)	1.5 (2.8)
Cocaine mean (SD)	6.0 (8.0)	6.2 (8.1)
Route of Administration		
Heroin	(n=176)	(n=146)
Intranasal	60.6%	61.6%
Intravenous	38.8%	37.7%
Other Opioids	(n=143)	(n=115)
Intranasal	7.4%	7.8%
Oral	91.2%	90.4%
Smoking	1.5%	1.7%
Cocaine	(n=136)	(n=115)
Intranasal	24.0%	24.4%

	All Participants	Participants with Stress Events
Smoking	54.1%	54.8%
Intravenous	21.8%	20.9%
Urine drug screen results		
Opioids mean % negative (SD)	61.8% (38.2)	61.0% (36.7)
Cocaine mean % negative (SD)	66.2% (39.6)	65.2% (39.8)
Cannabis mean % negative (SD)	85.8% (29.3)	85.9% (29.0)

Table 3

Companions, location, and activities during self-initiated reports of stress events (SEs) versus those present during randomly prompted entries (RPs)

	F(1,156)	FDR p	OR (95%CI)	Yes: % SEs	No: % SEs	r _{effect} within	r _{effect} between
<u>Companion type</u>							
Risk factors for stress							
Acquaintances	109.21	.0110	2.83 (2.32, 3.44)*	6.8	2.5	0.63*	0.24*
Coworkers	15.36	.0006	1.61 (1.26, 2.04)*	4.1	2.6	0.28*	0.13
Gate partner	9.06	.0006	2.65 (1.61, 4.34)*	6.7	2.6	0.31*	0.07
Strangers	5.70	.0368	1.31 (1.05, 1.64)*	3.4	2.6	0.17*	0.15
Friends	5.60	.0370	1.24 (1.04, 1.48)*	3.2	2.6	0.17*	0.13
Protective from stress							
No one	10.71	.0033	0.83 (0.74, 0.93)*	2.4	2.9	-0.26*	-0.01
Child	6.72	.0033	0.74 (0.58, 0.93)*	2.0	2.7	-0.18*	-0.17*
Not associated with stress							
Spouse/partner	4.28	.07	0.85 (0.73, 0.99)	2.4	2.8	-0.14	-0.12
Other family	0.44	.61	0.85 (0.81, 1.11)	2.5	2.7	-0.07	-0.12
Clinic staff or patients	0.01	.97	1.01 (0.77, 1.32)	2.7	2.7	0.01	0.09
<u>Location type</u>							
Risk factors for stress							
Bar or club	18.87	.0004	3.83 (2.05, 7.18)*	10.1	2.8	0.32*	0.24*
Outside hanging out	13.72	.0004	1.69 (1.28, 2.24)*	4.5	2.8	0.28*	0.03
Walking	13.14	.0004	1.54 (1.22, 1.96)*	4.3	2.8	0.28*	0.02
Waiting for ride	9.30	.0004	1.32 (1.10, 1.57)*	3.7	2.8	0.22*	0.25*
Protective from stress							
Home	86.96	.0004	0.61 (0.55, 0.68)*	2.2	3.6	-0.59*	-0.18*
Another's home	37.68	.0004	0.46 (0.36, 0.59)*	1.4	3.0	-0.44*	0.02
Other (not on dropdown list)	17.67	.0004	0.65 (0.53, 0.80)*	1.9	3.0	-0.32*	0.03
Not associated with stress							

	F(1,156)	FDR p	OR (95%CI)	Yes: % SEs	No: % SEs	r _{effect} within	r _{effect} between
Work	2.09	.24	0.86 (0.70, 1.06)	2.5	2.9	-0.11	-0.01
Abandonment	2.08	.26	1.69 (0.77, 3.73)	4.7	2.9	0.11	0.09
Vehicle	1.67	.29	1.10 (0.95, 1.28)	3.1	2.8	0.10	0.09
Shelter	1.29	.39	1.82 (0.62, 5.35)	5.1	2.9	0.09	-0.01
Store	1.02	.42	1.16 (0.87, 1.56)	3.3	2.0	0.09	-0.05
Restaurant	0.51	.60	0.82 (0.47, 1.42)	2.4	2.9	-0.06	0.05
Church	0.42	.61	1.32 (0.55, 3.16)	3.7	2.9	0.05	0.09
Clinic	0.03	.90	0.98 (0.79, 1.21)	2.8	2.9	-0.02	0.11
<u>Activity type</u>							
Risk factors for stress							
Arguing	288.72	.0004	8.23 (6.43, 10.53)*	17.9	2.6	0.80*	0.19*
Other (not on dropdown list)	51.42	.0004	2.49 (1.94, 3.21)*	6.3	2.6	0.49*	0.06
Waiting	46.30	.0004	1.88 (1.56, 2.25)*	4.8	2.6	0.48*	0.04
Walking/riding	36.95	.0004	1.42 (1.27, 1.59)*	3.5	2.5	0.42*	0.28*
On phone	33.14	.0004	1.90 (1.52, 2.37)*	4.9	2.7	0.41*	0.18*
Talking/socializing	26.45	.0004	1.44 (1.25, 1.66)*	3.7	2.6	0.38*	0.07
Protective from stress							
Resting/sleeping	95.34	.0004	0.48 (0.41, 0.55)*	1.5	3.1	-0.62*	0.01
Watching TV	57.29	.0004	0.57 (0.49, 0.66)*	1.7	3.0	-0.51*	-0.23*
Eating	27.42	.0004	0.55 (0.44, 0.69)*	1.6	2.8	-0.40*	-0.16*
On Internet	8.20	.0110	0.56 (0.38, 0.84)*	1.6	2.8	-0.22*	-0.02
Not associated with stress							
Shopping/errands	3.88	.09	1.33 (0.99, 1.78)	3.6	2.7	0.16	0.01
Thinking	3.53	.11	1.17 (0.99, 1.37)	3.1	2.7	0.13	0.09
Copping (buying drugs)	2.59	.18	1.78 (0.87, 3.65)	4.7	2.7	0.12	0.11
Hustling for money	1.03	.42	1.44 (0.70, 2.93)	3.9	2.7	0.08	0.04
Listening to music	0.98	.42	1.14 (0.88, 1.48)	3.1	2.7	0.08	0.02
Chores/hygiene	0.96	.42	1.12 (0.90, 1.39)	3.0	2.7	0.08	-0.04
Illegal activities	0.33	.66	1.23 (0.59, 2.56)	3.3	2.7	0.04	0.07

	F(1,156)	FDR p	OR (95%CI)	Yes: % SEs	No: % SEs	r_{effect} within	r_{effect} between
Sports/games/recreation	0.28	.67	0.87 (0.51, 1.48)	2.4	2.7	-0.04	-0.01
Working	0.18	.73	0.96 (0.79, 1.16)	2.6	2.7	-0.04	0.01
Child or elder care	0.09	.82	1.07 (0.68, 1.67)	2.9	2.7	0.02	0.01
Reading	0.02	.90	0.98 (0.70, 1.35)	2.7	2.7	-0.02	0.05

Note. Results in the first four columns are from Glimmix models in which the predictor was the presence versus absence of the companion and the dependent variable was the type of entry (stress event versus random prompt). In the raw data from the 158 participants who made stress entries, 4.3% of all EMA entries were stress entries (1,740 / (1,740+38,768)). The columns “Yes: % SEs” and “No: % SEs” show model-adjusted rates of stress entries, in the presence versus absence of the each type of companion. Model-adjusted rates tended to be lower than the rate in the raw data; we report them to make the statistical output more concrete.

The last two columns, “r_{effect} within” and “r_{effect} between,” are from additional Glimmix models in which each overall association was decomposed into relationships that occurred over time within participants (r_{effect} within) versus differences between participants (r_{effect} between). F values from those models were used to calculate r_{effect} sizes, which can take the same range of values as Pearson correlation coefficients.

* FDR-adjusted p value < .05.