Published in final edited form as:

Addict Behav. 2013 October ; 38(10): 2485–2491. doi:10.1016/j.addbeh.2013.05.010.

Daily Temporal Patterns of Heroin and Cocaine Use and Craving: Relationship with Business Hours Regardless of Actual Employment Status

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Abstract

Real-time monitoring of behavior using Ecological Momentary Assessment (EMA) has provided detailed data about daily temporal patterns of craving and use in cigarette smokers. We have collected similar data from a sample of cocaine and heroin users. Here we analyzed it in the context of its relationship with a societal construct of daily temporal organization: 9-to-5 business hours. In a 28-week prospective study, 112 methadone-maintained polydrug-abusing individuals initiated an electronic-diary entry and provided data each time they used cocaine, heroin, or both during weeks 4 to 28. EMA data were collected for 10,781 person-days and included: 663 cocaine-craving events, 710 cocaine-use events, 288 heroin-craving events, 66 heroin-use events, 630 craving-both-drugs events, and 282 use-of-both-drugs events. At baseline, 34% of the participants reported full-time employment in the preceding 3-year period. Most participants' current employment status fluctuated throughout the study. In a generalized linear mixed model (SAS Proc Glimmix), cocaine use varied by time of day relative to business hours ($p < 0.0001$) and there was a significant interaction between Day of the Week and Time Relative to Business Hours ($p < 0.002$) regardless of current work status. Cocaine craving also varied by time of day relative to business hours ($p < 0.0001$), however, there was no significant interaction between Day of the Week and Time Relative to Business Hours ($p = .57$). Heroin craving and use were mostly reported during business hours, but data were sparse. Cocaine craving is most frequent during business hours while cocaine use is more frequent after business hours. Cocaine use during business hours, but not craving, seems suppressed on most weekdays, but not weekends, suggesting that societal conventions reflected in business hours influence drug-use patterns even in individuals whose daily schedules are not necessarily dictated by employment during conventional business hours.

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Contributors

KLP and DHE designed the study and wrote the protocol. KAP conducted literature searches and provided summaries of previous research studies. DHE conducted the statistical analysis. KAP wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

Conflict of Interest

All authors declare that they have no conflicts of interest.

Keywords

Ecological Momentary Assessment; cocaine; heroin; craving/use; business hours

1. Introduction

In a classic series of writings, Zinberg and colleagues (1978; 1975) postulated that patterns of drug use are influenced by three groups of variables: drug variables (properties of the drug itself), set variables (users' personalities and attitudes—that is, their mental “set”), and setting variables (the physical and social setting in which the drug use occurs). The setting variable incorporates the concepts of social sanctions (norms and beliefs about how the drug should be used) and rituals (stylized drug use behaviors and practices including times and places for use, choice of companions, etc.). Social sanctions can then be internalized by small groups and more broadly by society as a whole and are reinforced via mass media and by personal observation as part of a social learning process.

Building on Zinberg's work, research has continued to show that stress and the environment affect drug-use patterns. For example, our electronic-diary studies have shown that patterns of drug use and abstinence are associated with distinct patterns of mood and behavior (Epstein, Marrone, Heishman, Schmittner, & Preston, 2010; Epstein & Preston, 2010; Epstein et al., 2009; Preston et al., 2009). In one set of analyses, we examined behaviors across the day (as reported at randomly timed prompts) during urine-verified periods of cocaine use and abstinence. We found that periods of cocaine use were associated with idle, solitary, affectively negative afternoons and with greater likelihood of early-morning or late-evening work (Epstein & Preston, 2010). The latter finding, which was unexpected, might mean that our participants were utilizing the stimulant properties of cocaine to be more alert for shift work.

In the analyses reported here, we focus on time-stamped individual self-reports of drug craving and use rather than on urine-based classifications of use/abstinence periods. Our broad question was how drug use and craving are distributed across hours and days. More specifically, we wondered whether this distribution would reflect the pervasive societal construct of “business hours” (which, in the US, are conventionally understood to occur 9am to 5pm Monday through Friday), despite the fact that few of our participants report full-time work and fewer still report a 9-to-5 job. One possibility is that underemployed polydrug misusers largely disregard such conventions, but another possibility is that, in some ways, they implicitly abide by them.

2. Methods

2.1 Participants and Setting

Participants were poly-substance misusers (all used heroin and cocaine) who were enrolled in methadone maintenance as part of a 28-week Ecological Momentary Assessment (EMA) study of drug craving and use during treatment. Other analyses from this dataset have been reported (Epstein et al., 2010; Epstein & Preston, 2010; Epstein et al., 2009; Preston et al., 2009). All participants met DSM-IV criteria for cocaine dependence by structured interview (Robins et al. 1995) at study intake, though this was not an inclusion criterion. The main inclusion criteria for the study were: 1) age between 18 and 65 years, 2) physical dependence on opioids, and 3) evidence of cocaine and heroin use. Exclusion criteria were: 1) current psychotic disorder, history of bipolar disorder, or current major depressive disorder, 2) current dependence on alcohol or any sedative-hypnotic drug, 3) cognitive impairment severe enough to preclude ability to provide informed consent, and 4) medical

illness that would compromise study participation. Physical dependence on opioids was determined by history and physical exam. Evidence of heroin and cocaine use was determined by self-report and/or urine drug testing. The Diagnostic Interview Schedule, version IV (Robins, Cottler, Bucholz, & Compton III, 1995), was used to determine presence of psychiatric diagnoses. An estimated IQ of less than 80 on the Shipley Institute for Living Scale (Shipley, 1940) was considered severe cognitive impairment and resulted in study exclusion. Medical illness precluding participation was determined by history, physical exam, laboratory assessment, and electrocardiogram, and dependence on alcohol or sedatives was determined by DSM-IV criteria. Eligibility for study participation was based on a chart review by the physician.

After study enrollment, participants began opioid agonist treatment (OAT) with methadone in our outpatient substance abuse treatment program in Baltimore, MD. All participants received daily directly-observed methadone with a target dose of 100mg/day, thrice-weekly urine drug testing, and weekly individualized counseling for up to 28 weeks. Clinic hours were from 11am to 1pm and 4–6:30pm Monday through Friday and 9–11am on Saturday and Sunday. During weeks 7–18, abstinence was reinforced: vouchers were provided for negative urine drug tests for heroin, cocaine, or both, with maximum earnings of \$2310 if abstinent for the entire 12 week period.

The Institutional Review Board (IRB) of the NIDA Intramural Research Program approved the study. All participants provided informed consent prior to study participation.

2.2 Study Design

The study was designed to explore the natural history of craving and relapse utilizing EMA against a backdrop of OAT with methadone and abstinence reinforcement (Epstein et al., 2009). At the end of the third week, participants received and were trained to use a personal digital assistant (PDA, i.e., Palm Zire or Palm Zire 21, Palm, Inc. Sunnyvale, CA), which ran our Transactional Electronic Diary (TED) software (Vahabzadeh, Epstein, Mezghanni, Lin, & Preston, 2004). Participants made two types of EMA entries: 1) randomly prompted entries, which were randomly triggered 2 to 5 times per day, and 2) event-contingent entries, which participants self-initiated when they craved or used cocaine or heroin. For both types of entries, participants were asked to enter information on whom they were with, what they were doing, where they were, and their current mood. The random-prompting hours were programmed for each individual according to his or her self-reported typical waking and sleeping hours for each day of the week. The analyses in this report use data from the event-contingent entries only.

Data on the “who,” “what,” “where,” and mood variables were obtained with a series of questions with multiple-choice responses or checkboxes. These findings have been described previously (Epstein & Preston, 2010). Data on the “when” variable were obtained from the time stamp automatically associated with each EMA entry.

Data on current work patterns were obtained from retrospective chart review of participants’ weekly sessions with a counselor/case manager. We coded them as “employed full-time,” “employed part-time,” and “unemployed.”

2.3 Data Analysis

We had participants report six types of events that were treated as mutually exclusive: cocaine craving; cocaine use; heroin craving; heroin use; simultaneous craving for cocaine and heroin; and simultaneous use of cocaine and heroin. A craving episode that did not result in use was counted only as a craving episode whereas a craving episode that resulted in use was only counted as a use episode. The primary goal of the analysis was to determine,

within the universe of days on which an event was reported at all, how the reports were distributed across the day. Therefore, for each of the six types of events, we constructed a data set consisting only of days on which an event was reported. As part of the initial examination of the data, we graphed the frequency of these events across the day. These graphs suggested that the frequency of events varied systematically by time of day and day of the week, with craving events peaking earlier than drug-use events and a possible relationship of both types of events to business hours.

To examine this possibility, on each day that a participant reported an event, each hour was classified as “event” or “no event” (the dependent variable) and also as “before business hours” (midnight to 9:00 AM), “during business hours” (9:00 AM to 5:00 PM, conventional US business hours), and “after business hours” (5:00 PM to midnight). The hours between 9:00 AM and 5:00 PM were classified as business hours for all seven days of the week. For each of the six data sets, we ran a generalized linear mixed model (SAS Proc Glimmix) with the binary dependent variable “event” (yes or no) and two time-varying predictors: Day of the Week (7 levels) and Time Relative to Business Hours (3 levels), along with their interaction. A significant interaction would indicate a differential effect of 9-to-5 hours on different days of the week (e.g., Monday-Friday versus Saturday and Sunday). For the cocaine use data set, Work Status (3 levels: full-time, part-time, unemployed) was included as a time-varying covariate. Each Glimmix analysis was followed by Tukey-Kramer pairwise comparisons. For two of the six data sets (see below), the data were relatively sparse and the two-factor Glimmix analysis would not converge (arrive at a solution), so the two independent variables were each tested in a separate Glimmix analysis. For all analyses, the criterion for significance was $p = 0.05$, two-tailed.

3. Results

One hundred and thirty participants (84 men, 46 women) enrolled in the study and 112 (71 men, 41 women) remained in the study at the end of 3 weeks and were issued a PDA. We found no significant demographic differences between the 112 included in the current analyses and the 18 who were not. Participants' mean age was 40.7 (SD 8.1, range 20–58), further demographic data are presented in the Table. At study intake, heroin use had occurred on an average of 29.3 of the past 30 days (SD 3.3, range 5–30) with main route of administration intravenous (61%) and intranasal (39%), and cocaine use had occurred on an average of 20.0 of the past 30 days (SD 9.2, range 4–30) with main route of administration smoking (48%), intravenous (42%), and intranasal (8%). EMA data were collected for 10,781 person-days and included the following mutually exclusive events: 663 cocaine craving (in 77 individuals), 710 cocaine use (in 70 individuals), 288 heroin craving (in 52 individuals), 66 heroin use (in 26 individuals), 630 craving both cocaine and heroin (in 85 individuals), and 232 use of both cocaine and heroin (in 55 individuals).

3.1 Use and Craving – Day of the Week

Heroin use and craving and simultaneous use of heroin and cocaine was relatively consistent across the days of the week, while cocaine craving and use and simultaneous craving for both drugs showed some variation across the week, the numbers of events tending to be lower on Sundays and Mondays (Figures 1, 2 and 3). Nevertheless, there were no significant effects of Day of the Week on any type of entry: cocaine use [$F(6,195)=1.58$, $p=0.15$], cocaine craving [$F(6,199)=0.52$, $p=0.80$], heroin use [$F(6,18) = 0.01$, n.s.], heroin craving [$F(6,91) = 0.21$, n.s.], simultaneous use [$F(6,81) = 0.40$, n.s.], and simultaneous craving [$F(6,183) = 0.18$, n.s.].

3.2 Use and Craving – Time of Day Relative to Business Hours

3.2.1 Cocaine—Cocaine use varied by time of day relative to business hours

[F(2,138)=78.40, $p<0.0001$]. On most weekdays, use was significantly greater after business hours than before or during, tending to peak just as business hours were ending. There was also a significant interaction between Day of the Week and Time Relative to Business Hours [F(12,390)=2.71, $p<0.002$], reflecting greater suppression of cocaine use during conventional Monday-Friday business hours than during the corresponding hours on weekends (Figure 1). These findings remained essentially unchanged after accounting for each participant's actual current work status as a time-varying covariate (Time Relative to Business Hours [F(2,132)=78.03, $p<0.0001$] and the interaction between Day of the Week and Time Relative to Business Hours [F(12,366)=2.34, $p=0.0068$]. The findings also remained unchanged when, in two sensitivity analyses, we included a control term for either sex or race (separately, to avoid overspecifying the models); neither sex nor race had a main effect on cocaine use, and neither changed the other observed effects.

Cocaine craving also varied by time of day relative to business hours [F(2,152)=122.74, $p<0.0001$]. On most days, craving was significantly greater *during* business hours than before or after (Figure 3). However, there was no significant interaction between Day of the Week and Time Relative to Business Hours [F(12,398)=0.88, $p=.57$]. The absence of the interaction suggests that cocaine craving was not suppressed (as use was) during conventional Monday-Friday business hours (Figure 1).

3.2.2 Heroin—There were too few heroin-use data points to support a Glimmix analysis of the interaction between business hours and day of the week (the analysis did not converge), so each of the two factors was examined separately. Heroin use varied as a function of business hours [F(2,50) = 9.70, $p = .0003$]; unlike cocaine use, heroin use was reported primarily *during* business hours rather than after (Figure 2).

For heroin craving, data were sufficient to examine both predictors and their interaction. Heroin craving varied as a function of business hours [F(2,102) = 11.24, $p < .0001$]. Like cocaine craving, heroin craving was reported primarily *during* business hours. There was no significant interaction between Day of the Week and Time Relative to Business Hours [F(12,182) = 0.79, n.s.] (Figure 2).

3.2.3 Use of, and craving for, cocaine and heroin simultaneously—Simultaneous use varied as a function of time relative to business hours [F(2,108) = 27.57, $p < .0001$]: like heroin, and unlike cocaine, simultaneous use was most likely to be reported *during* business hours, not after. There was no interaction between Day of the Week and Time Relative to Business Hours [F(12,162) = 1.23, n.s.] (Figure 3).

For simultaneous craving, there were too few data points to support a Glimmix analysis of the interaction between business hours and day of the week. Analysis of each separately showed that, like heroin craving, simultaneous craving varied as a function of business hours [F(2,168) = 138.93, $p < .0001$]; like craving for cocaine or heroin individually, it was most likely to be reported *during* business hours (Figure 3).

4. Discussion

We found that cocaine craving appears to be higher during conventional US business hours than before or after business hours. In contrast, cocaine use appears to increase throughout the day with the peak usage after business hours. This finding is consistent with prior findings that craving precipitates use (Robbins & Ehrman, 1998; Sinha, Garcia, Paliwal, Kreek, & Rounsaville, 2006). Given that only 34% of our population reported full-time

employment, that their current work status did not alter the relationship between cocaine use and time of day relative to business hours, and that employment in our population is often shift work (e.g., custodial, factory work, etc.) occurring outside the 9-to-5 business day, this also suggests that the social conventions reflected in 9 to 5 business hours may influence cocaine craving and use patterns even in cocaine users whose daily schedules are not necessarily dictated by conventional business hours. This finding may reflect an internalization of social sanctions as postulated by Zinberg (1980) examples of which include, “It is all right to have a drink at the end of the day or a few beers on the way home from work, or in front of the television, but don’t drink on the job” (Zinberg, 1980). Alternatively, it may suggest an effect of other environmental factors tied to business hours, such as availability of cocaine or availability of cocaine-using partners.

Unlike the pattern with cocaine use, we found that heroin use more often occurred during business hours. The lack of delay in heroin use until after business hours may reflect the fact that there were very few heroin-use events (likely due to the receipt of adequate methadone doses) and that those who continue to use heroin while on methadone may represent a small group of heavier users who are less aware of societal conventions such as business hours. Another possibility is that heroin craving during business hours might be accompanied by symptoms of opiate withdrawal, avoidance of which precluded waiting until after conventional business hours.

The increased use of both cocaine and heroin during business hours may have been driven primarily in the same way. Given that all of the participants in the study were on OAT, methadone administration likely influenced the time and frequency of heroin use, and the patterns of heroin use shown in this study probably do not reflect those of untreated heroin-dependent individuals. A clear limitation of our heroin-use data is the relatively small number of episodes reported, especially relative to cocaine use. We believe this reflects a combination of the longer duration of action of heroin, the fact that our participants were on OAT, and the likelihood that the acute effects of heroin could interfere with reporting.

One possible limitation of our study is that the data were obtained by self-report, which could raise concerns about its accuracy. Comparison of our EMA self-report data with thrice-weekly urine toxicologies from the same participants (data not shown) shows that not all use events were reported. However, our findings were consistent regardless of participants’ actual current employment statuses, strongly suggesting that the apparent effect of business hours on drug use was not simply an artifact of nonreporting by participants who were in their workplaces.

Another possible limitation, and a subject for future study, is that we do not know the employment status and work schedules of our participants’ primary drug-using partners. For example, some participants may have delayed cocaine use until after 5pm as a result of waiting until their drug-using partners came home from full-time work.

The generalizability of our study is limited to heroin and cocaine users in methadone treatment. We are unable to speculate whether similar patterns of craving and use might be impacted by conventional norms and business hours in polysubstance users not in treatment, individuals using other drugs, or individuals in treatment other than methadone maintenance.

Our study has several strengths, including the use of EMA to obtain real-time in-the-field reports of drug craving and use with automatic time and date stamping, allowing for accurate mapping of drug craving and use throughout the day with minimal recall bias. Another strength is that the collected data encompass over 2500 mutually exclusive episodes of craving or use over a period of 6 months for each participant, an event frequency and timeframe that, for most participants, captured several different points on the continuum of

formal and informal employment status. Additionally, the data set contains cocaine and heroin events occurring independently and concurrently, permitting evaluation of whether “heroin and cocaine” events are patterned more like “heroin alone” events or “cocaine alone” events (the former was the case).

The implications of our findings are several-fold. First, on a treatment level, providers might account for the possible impact of the conventional 9–5 business hours construct when exploring drug use triggers and working with patients to develop skills to handle craving and avoid use. On a systems-level, clinics might consider the daily temporal patterns of craving and use when designating clinic hours and counselor and other staff availability. On a policy level, communities might also try to ensure treatment resources are available after 5pm, when cocaine use is highest.

5. Conclusions

In summary, our data indicate that cocaine craving appears greatest during conventional US 9 to 5 business hours and cocaine use greatest after business hours. This finding suggests that even among a largely unemployed and non-traditionally employed cohort, the social convention of 9-to-5 business hours has an impact and is a sign of the cultural pervasiveness of what “business hours” mean. Further research is needed to explore the intricacies of employment arrangements and schedules of drug users and their partners on drug craving and use patterns.

Acknowledgments

The authors wish to thank the NIDA IRP Archway Clinic staff and participants.

Role of Funding Sources

This research was supported by the Intramural Research Program (IRP) of the National Institute on Drug Abuse (NIDA), National Institutes of Health and the NIH Genes, Environment and Health Initiative Z01-000499.

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Highlights

- Cocaine craving appears greatest during conventional 9 to 5 business hours
- Cocaine use appears greatest after business hours
- Even among the unemployed, the convention of 9-to-5 business hours influences cocaine craving and use patterns

Figure 1.

Distribution of 663 cocaine-craving events and 710 cocaine-use events across days and hours in 112 participants monitored for up to 25 weeks. The gray shaded area represents conventional business hours (9am to 5pm). The asterisks represent significant pairwise differences between portions of the day (“before,” “during,” and “after” business hours) in Tukey-Kramer pairwise comparisons; the stepped horizontal lines below the asterisks show schematically the direction of each difference (increase or decrease). Statistics for the two main effects (Day of the Week, and Time Relative to Business Hours) are given in the Results.

Figure 2.

Distribution of 288 heroin-craving events and 66 heroin-use events. Details are the same as in Figure 1. For heroin-use events, a two-factor analysis would not converge, so no Tukey-Kramer pairwise comparisons were possible. Statistics for the two main effects (Day of the Week, and Time Relative to Business Hours) are given in the Results.

Figure 3.

Distribution of 630 “heroin and cocaine”-craving events and 282 “heroin and cocaine”-use events. Details are the same as in figure 1. For craving events, a two-factor analysis would not converge, so no Tukey-Kramer pairwise comparisons were possible. For use events, pairwise comparisons were made, but not were significant, presumably due to the relative sparsity of data. Statistics for the two main effects (Day of the Week, and Time Relative to Business Hours) are given in the Results.

Table

Demographic characteristics of study participants at intake (n=112)

Demographic characteristic	Percent
African-American	61%
European-American	37%
Hispanic	2%
Unemployed	38%
Employed part-time	27%
Employed full-time	34%
Never married	63%
Separated, divorced, or widowed	28%
Married	9%
Lived with parents or other family	45%
Lived with spouse/partner alone	17%
Lived with spouse/partner and children	10%
Lived with friends	14%
Had a functioning car available for personal use	13%