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Cell phone-based ecological momentary assessment of substance use context for Latino youth in outpatient treatment: Who, what, when and where

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ABSTRACT

Background: Relationships between alcohol, marijuana and other drug (AOD) use and contextual factors have mostly been established through retrospective self-report. Given the embeddedness of cell phones in adolescents' daily activities, cell phone-based ecological momentary assessment (CEMA) provides an opportunity to better understand AOD use in youth and how cell phones can be used to self-monitor and deliver interventions. We use CEMA to examine AOD use in Latino youth who have been especially understudied.

Methods: Twenty-eight mostly Latino youth (ages 13–18) in outpatient substance abuse treatment recorded AOD use, contextual factors, cravings, and affect through once-daily CEMA over one month periods. Random-effects logistic regression was used to compare contextual factors between periods of AOD use and non-use.

Results: The most frequent contextual factors reported during AOD use were being with close friends and "hanging out" as the primary activity. During AOD use compared to non-use, youth were more likely to be with close friends (OR = 4.76; $p < 0.01$), around users (OR = 17.69; $p < 0.01$), and at a friend's house (OR = 5.97; $p < 0.01$). Alcohol use was more frequently reported at night (63% vs 34%) and on weekends relative to other substances (64% vs 49%). Strong cravings were more frequently reported on AOD-use days (OR = 7.34; $p < 0.01$). Types of positive and negative affect were reported with similar frequencies, regardless of AOD use.

Conclusions: Reporting on social context, location, day and time of day, and cravings all show promise in developing cell phone-based interventions triggered by contextual data.

1. Introduction

Mobile technologies have the potential to revolutionize treatment programs for adolescent substance users. Current practices center on cognitive-behavioral therapies (Dennis et al., 2002, 2004; Kaminer, 2001) in which youth engage in group therapy, and which rely on retrospective assessments to self-monitor and identify relapse triggers. Cell phones expand the feasibility and reach of ecological momentary assessment (EMA); events are recorded in near real-time as they occur to elicit ecologically-valid data, reduce reliance on autobiographical memory and reduce recall biases (Bradburn et al., 1987; Piasecki et al., 2007; Shiffman, 2009; Shiffman et al., 2008; Stone and Shiffman, 1994). Mobile technologies also enable ecological momentary interventions (EMI; Heron and Smyth, 2010), for example, as tested in cell phone-based smoking cessation interventions for youth (Whittaker et al., 2008).

Before EMI can be fully realized in supporting drug treatment, a greater degree of granularity is needed in understanding daily behaviors, social contexts, and internal states in order to optimize the personalization inherent in EMI. To date, most information on substance use and contextual factors has been captured through retrospective assessments. Cell phone-based EMA (CEMA) studies in treatment settings are crucial for EMI development, particularly for adolescents given the prevalence of substance use problems, especially in Latino youth, and the high use of cell phones in adolescents' daily routines (Pew Internet and American Life Project, 2013). Higher levels of alcohol and drug use across multiple categories have been shown for Latino youth in the 8th and 10th grades compared to African American and Caucasian youth (Johnston et al., 2012). Moreover, Latino youth with substance use disorders

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(SUD) are less likely to receive treatment than White adolescents (Cummings et al., 2011).

In this vein, we pilot tested CEMA of alcohol, marijuana, and other drug (AOD) use in a sample of mostly Latino youth in outpatient substance abuse treatment. We previously reported high compliance rate for completing CEMA reports (Comulada et al., 2015). Here we explore contextual factors that were assessed along with AOD use in order to fill gaps in the literature related to the context in which adolescent AOD use occurs. We highlight practical applications of our findings for the development of EMI. Our pilot study tested different CEMA strategies that would likely be used in a treatment setting, including prompted (alarm-based) daily recall and event-based (self-initiated) reporting. As a secondary aim, we examine if context related to AOD use that is reported during daily recall differs from context reported through event-based reporting. To the best of our knowledge, this has not been explored in prior studies.

First, we summarize AOD-related contextual factors that have been evaluated in prior adolescent studies and that are evaluated in our study. We hypothesize similar findings in our sample, although we do so with caution. Prior research has mostly focused on social-contextual factors (Goncy and Mrug, 2013); this study makes a valuable contribution to the literature by giving equal attention to other contextual factors and affect. Moreover, prior findings are not generally based on Latino youth and are mostly based on retrospective assessments. Findings from (C)EMA studies are specified as such.

1.1. Who

Numerous studies have shown associations between AOD use in adolescents and AOD use in their peers (Kelly et al., 2012; Valente, 2010), as well as peer socioeconomic characteristics (van Dommelen-Gonzalez et al., 2015). What warrants further study are nuances in types of peer relations that relate to AOD use. For example, minority youth reported alcohol and marijuana use "among young people they knew", relative to other substances in a qualitative study (Criss et al., 2016). Similarly, a study of young Australians found the majority of drinking episodes to occur with "close friends" (Dietze et al., 2014).

1.2. What

Hanging out and sleeping or resting have both been more frequently reported by youth on drinking versus non-drinking days through CEMA (Kauer et al., 2009); youth also spent less time studying on drinking days. Drug use has been found to be less likely among adult drug users while eating based on CEMA (Linas et al., 2015).

1.3. When

Alcohol and marijuana use have been more frequently reported by youth on weekends versus weeknights and after school relative to time periods before or during school (Goncy and Mrug, 2013). This is in line with the notion that alcohol is easier to detect and more limited to nighttime and weekend parties as reported by youth in qualitative interviews (Criss et al., 2016). It has also been noted that youth use alcohol and marijuana to attenuate sleep problems and sleep disturbances from other substances, such as stimulants used to increase daytime alertness (Bootzin and Stevens, 2005).

1.4. Where

A recent study of youth found marijuana to be most frequently used at a "friend's house" and alcohol use to be split between use at "one's own home" or at a "friend's house" (Goncy and Mrug, 2013). In the same vein, a study of Australian youth found heavy drinking to be reported more frequently at a "private house" relative to public locations, such as a nightclub (Dietze et al., 2014).

1.5. Cravings and affect

Cravings have been extensively evaluated through EMA and are associated with AOD use; see Serre et al. (2015) for a review. Affect has also been studied through EMA, although findings have been inconclusive with both positive and negative affect showing association with AOD use. Kauer et al. (2009) found higher negative mood on days when alcohol was consumed relative to non-drinking days in youth. In adult populations, alcohol consumption has been associated with both happiness and nervousness (Swendsen et al., 2000). Reports of anger have been associated with reduced drug use (Linas et al., 2015).

2. Methods

2.1. Participants

Youth were recruited from an adolescent outpatient substance abuse treatment setting in a large U.S. city from 2010 to 2011. All youth were in the treatment program because they exhibited some degree of impairment in school, social, or family environments. Eligible youth were: 1) between the ages of 12–18, 2) enrolled in treatment with an expected duration of at least a month, 3) able to use a cell phone, and 4) English speaking in order to fill out the CEMA (although language was not a barrier as all youth encountered spoke English). Youth who were 18 years old signed a consent form while younger youth signed assent forms and parental consent was also obtained.

Participating youth received a $15 gift certificate for completing a baseline assessment. Over the course of the study, participants received $25 per week and 500 free cell phone minutes per month. Study procedures were approved by the Institutional Review Board of the University (Comulada et al., 2015).

2.2. Procedures

After screening and consent, participants were administered a baseline assessment, assigned study cellular phone, and trained to fill out the CEMA. Youth were then assigned to one of three text message-based CEMA strategies (i.e., prompting and instructions) deemed to be appropriate in a treatment setting:

- End-of-day *assessment* (EoDA): Youth received an automated text assessment once per day at 9:00 p.m. and were asked about AOD use, context, and affect *today*.
- *Random assessment* (RA): Youth received one automated assessment per day at a random time between 3:00 p.m. and 9:00 p.m. The timeframe for RA was chosen so that CEMA would not occur during school hours. Youth were asked about AOD use that occurred *since the last survey* (i.e., "Since the last time you completed a survey did you use . . ."). Youth who indicated AOD use were queried on context and affect before they used. Youth were then asked about AOD use, context, and affect *in the moment* (e.g., "Who are you hanging out with now?"). Youth received in-the-moment context and affect questions, whether or not AOD use was indicated.
- *Event-based assessment* (EBA): Youth were instructed to text a six-digit code to initiate the CEMA survey whenever they engaged in AOD use. Similar to RA, youth were queried on context and affect *in the moment*.

Assignment to a CEMA strategy was based on anticipated AOD use; youth who were newly enrolled in treatment were more likely to be assigned to EBA than remaining strategies because they were anticipated to have more AOD use events to report. Youth participated in multiple one-month CEMA periods (up to four) and were rotated through different assessment strategies so that the likelihood of repeating the same assessment strategy was low. During the last two assessment periods, youth could also be assigned to a combination assessment strategy in which youth received EoDA and were also asked to initiate EBA whenever they engaged in AOD use.

A total of 28 youth were enrolled. Eleven youth were initially enrolled and followed for one month with four youth assigned to EoDA, three youth assigned to EBA, and four youth assigned to RA. After the initial assessment period, youth could participate in three more month-long assessment periods with month-long breaks in between assessment periods. Six new youth were enrolled during the second assessment period, three youth during the third assessment period, and eight youth were enrolled during the last assessment period. Half of the participants participated in two or more month-long CEMA periods (n = 14 of 28). Four youth participated in all four possible assessment periods.

2.3. Measures

Demographic characteristics and AOD use rates were assessed at baseline. Remaining measures were collected through CEMA. Question time-framing was based on the CEMA prompt type. EoDA and RA were filled out on a *daily* basis. RA also asked youth to report on AOD use *in the moment*, along with EBA. An important distinction between in-the-moment RA and EBA, is that EBA was only reported during AOD use. All questions contained response categories to choose from, including an "Other" category that allowed youth to enter an open-ended response. Youth were allowed to select more than one response category. Details on CEMA measures follow and are presented by content area.

2.3.1. AOD use. Youth were asked if they "used any alcohol" and if they "used any drugs" and prompted with "Yes" or "No" responses. Youth who indicated drug use were prompted to answer if they used "Marijuana", "Ecstasy", "Cocaine/Crack", "Inhalants", "Hallucinogens", "Painkillers", or "Meth".

2.3.2. Who. Youth were asked if they *used AOD with* "Close friends", "Crew/Gang", "School friends", "Family/Relatives", "Girlfriend/Boyfriend", "Strangers", or "No one" during daily report. The question was slightly rephrased for in-the-moment queries to ask if "around users".

2.3.3. What. Youth were asked what they were doing in the moment during RA and EBA with categories for "Hanging out", "Watching a movie", "Exercising", "Eating", and "Shopping".

2.3.4. When. Date and time stamps were used to determine day of week when reports were filled out for all assessments. Timestamps for when assessments were initiated were used to report when AOD was used for in-the-moment reports. For EoDA, youth were asked if they used AOD "In the morning", "In the afternoon", or "At night".

2.3.5. Where. Youth were asked where they were when they used AOD during daily report. Locations included a "Friend's house", "Party", "My house", "School", "In the park", "Abandoned house", or at the "Movies". The question was slightly rephrased for in-the-moment queries to ask "Where are you now?".

2.3.6. Cravings. Youth were asked about the intensity of their AOD cravings, categorized as "Really bad" (hereafter referred to as "Strong"), "Not that much", "No craving", and "Can't use". Youth were only asked about their cravings "today" during EoDA and "now" during in-the-moment RA.

2.3.7. Affect. Youth were asked about their feelings before AOD use for daily and in-the-moment reports, categorized as "Stressed", "Irritated", "Happy", "Sad", "Pissed", "Nervous", or "Bored". Youth were also asked about feelings "today" during EoDA and "now" during in-the-moment RA.

2.3.8. Reasons for use. If youth indicated AOD use during daily or in-the-moment reports, they were asked what went through their mind before use, categorized as "Had a bad day", "Want2 relax", "Want2 feel better", "Want2 fit in", "Deserve it", or "Want2 get buzzed".

2.4. Data analyses

We present descriptive statistics for contextual factors, affect, and cravings by types of AOD. There was a high degree of overlap between reported use of alcohol and both marijuana and other drugs in the same reports. We categorize AOD use in a hierarchical fashion as use of alcohol only, use of marijuana and no other drugs, and use of other drugs. Use of marijuana and other drugs includes reports where alcohol use was also reported.

Assessment questions for daily reports (i.e., EoDA and RA) shared similar wordings, time frames, and results. In a parallel fashion, assessment questions for in-the-moment reports (i.e., RA and EBA) also shared similar properties and led to similar results. Results on daily reports and results on in-the-moment reports are grouped together for presentation.

Percentages for context, affect, and cravings are compared between CEMA when AOD use was and was not reported, where possible. Specifically, comparisons are made for affect and cravings reported during EoDA and for context, affect, and cravings reported during in-the-moment RA. Comparisons are conducted through random-effects logistic regression with random effects for each participant. Odds ratios (OR) and 95% confidence intervals (CI) are shown for significant comparisons. Models are fit in SAS software version 9.4 through the GLIMMIX procedure.

3. Results

3.1. Sample characteristics

Approximately half of the 28 study participants were male gender (57%; n = 16) and were on probation (46%; n = 13 males). Most participants were attending school (82%; n = 23). All but two participants identified as being Latino (93%; n = 26). The average and median age of participants was 16 years old (range = 13 to 18 years old). At baseline, most participants reported consuming alcohol (79%; n = 22) and about two thirds reported marijuana use (61%; n = 17) within the past 30 days. A little less than half of the participants reported using other drugs (43%; n = 12) that included stimulants, inhalants, party drugs, hallucinogens, cocaine or crack, and opiates.

3.2. CEMA reporting of AOD use

There was a total of 1303 text-message CEMA reports across the 28 study participants that closely matched the total number of days that study participants were in the study. Analysis data contains 601 EoDA, 614 RA, and 88 EBA. Analyses excluded CEMA

Table 1
Reports of AOD use, context and affect based on daily CEMA reports (n = 1215 reports).

CEMA question	Alcohol only 46 reports[a]	Marijuana 96 reports[a]	Other drugs 44 reports[a]
WHO used with you	Close friends 57% (26)[b] Family 15% (7)[b] Other 20% (9) No response 11% (5)	Close friends 45% (43) Crew/gang 19% (18) Other 35% (34) No response 1% (1)	Close friends 39% (17) No one 34% (15) Other 27% (12)
WHEN: Time of day	Night 57% (26)[b] Afternoon 26% (12)[b] Morning 13% (6) No response 7% (3)	Morning 43% (41) Afternoon 34% (33) Night 22% (21) No response 1% (1)	Afternoon 43% (19)[c] Night 36% (16)[c] Morning 25% (11)[c]
WHERE you used	Friend's house 43% (20)[b] Party 11% (6)[b] My house 11% (5) Other 26% (12) No response 9% (4)	School 27% (26) My house 22% (21) Friend's house 19% (18) Other 30% (29) No response 2% (2)	Friend's house 27% (12) Party 23% (10) School 20% (9) Other 30% (13)
FEELING before use	Happy 54% (25)[b] Bored 13% (6) Other 26% (12) No response 7% (3)	Happy 42% (40) Bored 32% (31) Other 24% (23) No response 2% (2)	Happy 48% (21) Stressed 16% (7) Other 34% (15) No response 2% (1)
REASONS for use	Get buzzed 57% (26)[b] Want relax 24% (11) Other 11% (5) No response 9% (4)	Want to relax 54% (52) Feel better 15% (14) Other 30% (29) No response 1% (1)	Want to relax 52% (23) Feel better 25% (11) Other 23% (10)
WHEN: Day of use[d]	Weekend 75% (15) Sunday 40% (8) Saturday 30% (6) Wednesday 15% (3) Other 15% (3)	Weekend 50% (15) Thursday 27% (8) Saturday 23% (7) Friday 20% (6) Other 30% (9)	Weekend 63% (10) Sunday 31% (5) Wednesday 19% (3) Friday 19% (3) Other 31% (5)
FEELING today[d]	Happy 65% (13) Bored 10% (2) Sad 10% (2) Other 15% (3)	Happy 57% (17) Stressed 20% (6) Other 23% (7)	Happy 63% (10) Bored 13% (2) Irritated 13% (2) Other 13% (2)
CRAVING today[d]	Strong 25% (5)	Strong 43% (13)	Strong 69% (11)

[a] Alcohol reports based on 16 youth, marijuana reports based on 19 youth, and other-drug reports based on 14 youth.
[b] Includes one report that included multiple response categories, e.g. use with close friends and family.
[c] Includes two reports that included multiple response categories.
[d] Only reported through end-of-day assessment: 20 reports for alcohol only, 30 reports for marijuana, and 16 reports for other drugs.

that resulted from glitches in the preprogrammed automated text-message CEMA or nonsensical response patterns.

Alcohol use, marijuana use, and use of other drugs was reported during 73%, 60%, and 48% of the rotations and similar to base rates. On daily basis, reported AOD use was low in EoDA and RA. For example, in EoDA, alcohol use was reported in 6% (n = 34) and substance use was reported in 8% (n = 48) of reports. Marijuana was the most frequently reported substance, accounting for approximately two thirds of substance use across CEMA strategies (i.e., 62.5% [n = 30] for EoDA, 71% [n = 68] for RA since the last survey, 10 of 11 or 91% of reports of AOD use for in-the-moment RA, and 51% [n = 25] for EBA). Remaining substances included ecstasy, cocaine or crack, inhalants, hallucinogens, painkillers, and methamphetamine. Poly-drug use was infrequent and only reported twice during RA since the last survey, including reports of marijuana use with ecstasy use or methamphetamine use. Approximately one in ten of EoDA and RA reports did not indicate whether or not AOD use occurred and were excluded from analyses (11% [n = 66] for EoDA, 12% [n = 75] for RA since last survey, and 15% [n = 92] for RA in the moment).

3.3. CEMA reporting of context related to AOD use

Tables 1 and 2 show contextual factors, affect, cognitions, and cravings by reported AOD use for daily or in-the-moment-based CEMA reporting strategies, respectively. For the sake of brevity, we only specify the top two or three categories for questions with many response choices; remaining categories are grouped with the "other" category. We summarize results below by contextual areas.

3.3.1. Who. Youth reported use of AOD with and around close friends about half the time (range = 39% to 60% in Tables 1 and 2 across types of AOD). Youth reported being by themselves for approximately a third of the reports when using other drugs. Youth reported to be around users a majority of the time when reporting in the moment (range = 72%–52%; Table 2). In-the-moment RA reports gave us the opportunity to compare social settings when AOD use was and was not reported. Youth were more likely to be around close friends during AOD use (45%) than non-use (14%; OR = 4.76, 95% CI = 1.85–12.28). During non-use, youth most frequently reported to be by themselves (34%) or with family (30%). Youth were also more likely to be around users during AOD use (50%) than non-use (6%; OR = 17.69, 95% CI = 6.23–50.27).

3.3.2. What. The most commonly reported activity during AOD use was hanging out (range = 52%–72%; Table 2) and was more likely to be reported during AOD use (55%) than during nonuse (40%) based on in-the-moment RA; this difference was not significantly different (OR = 1.73, 95% CI = 0.67–4.46).

3.3.3. When. AOD use was reported on the weekend (Friday, Saturday, or Sunday) about half the time (Tables 1 and 2), with alcohol use reported a little more often on weekends than marijuana or other drug use. For example, 56% of in-the-moment alcohol reports occurred on weekends versus 49% of marijuana reports and 40% of

Table 2
Reports of AOD use, context and affect based on in-the-moment CEMA reports (n = 702 reports).

CEMA question	Alcohol only 25 reports[a]	Marijuana 35 reports[a]	Other drugs 25 reports[a]
WHO is around you	Close friends 60% (15) Family 16% (4) Other 24% (6)	Close friends 46% (16) No one 20% (7) Other 34% (12)	Close friends 44% (11) No one 32% (8) Other 24% (6)
Around users	Yes 72% (18)	Yes 69% (24)	Yes 52% (13)
WHAT you are doing	Hanging out 52% (13) Watching movie 8% (2) Other 40% (10)	Hanging out 66% (23) Watching movie 11% (4) Other 23% (8)	Hanging out 72% (18) Other 28% (7)
DAY of use	Weekend 56% (14) Sunday 24% (6) Thu/Fri/Sat 16% (4) each day Other 28% (7)	Weekend 49% (17) Wednesday 29% (10) Saturday 20% (7) Friday 17% (6) Other 34% (12)	Weekend 40% (10) Wednesday 24% (6) Tuesday 20% (5) Saturday 16% (4) Other 36% (9)
WHERE you used	Friend's house 32% (8) My house 24% (6) Party 16% (4) Other 28% (7)	My house 54% (19) Friend's house 26% (9) Other 17% (6) No response 3% (1)	My house 28% (7) School 20% (5) Friend's house 16% (4) Other 36% (9)
FEELING now[b]	Happy 44% (4) Irritated 22% (2) Other 33% (3)	Happy 40% (4) Stressed 20% (2) Bored 20% (2) Other 20% (2)	Nervous 100% (1)
FEELING before use	Happy 56% (14) Bored 20% (5) Other 24% (6)	Bored 40% (14) Happy 37% (13) Stressed 11% (4) Other 11% (4)	Happy 28% (7) Bored 24% (6) Stressed 16% (4) Other 20% (5) No response 12% (3)
REASONS for use	Get buzzed 44% (11) Want relax 28% (7) Other 28% (7)	Want to relax 69% (24) Had a bad day 14% (5) Other 17% (6)	Want to relax 48% (12) Had a bad day 12% (3) Other activities 24% (6) No response 16% (4)
CRAVING now[b]	Strong 11% (1)	Strong 40% (4)	Strong 0% (0)
TIME of use[c]			
Random assessment[d]	Night (5–8p.m.) 56% (5) Afternoon (4–5p.m.) 44% (4)	Night (5–8p.m.) 60% (6) Afternoon (3–4p.m.) 40% (4)	Night (5p.m.) 100% (1)
Event-based assessment[e]	Night (6p.m.–3a.m.) 88% (14) Afternoon (12–2p.m.) 13% (2)	Night (5p.m.–2a.m.) 52% (13) Afternoon (12–4p.m.) 40% (10) Morning (7:17a.m.,10:10a.m.) 8% (2)	Night (5p.m.–1a.m.) 42% (10) Afternoon (2–4p.m.) 42% (10) Morning (6–10a.m.) 17% (4)

[a] Alcohol reports based on 14 youth, marijuana reports based on 15 youth, and other-drug reports based on 7 youth.
[b] Only reported through random assessment: 9 reports for alcohol only, 10 reports for marijuana, and 1 report for other drugs.
[c] Based on time-stamps that are grouped by naming conventions from daily reports: morning, afternoon, and night.
[d] Random assessment reported separately because reporting times are restricted to fall between 3 p.m.-9 p.m.
[e] Event-based assessment: 16 reports for alcohol only, 25 reports for marijuana, and 24 reports for other drugs.

other drug-use reports (Table 2). As a consistency check in filling out assessments, we note that EoDA and in-the-moment RA were filled out fairly evenly on all days when AOD use was not reported.

Alcohol use was reported at least half the time at night whether it was reported by recall (57%; Table 1) or in the moment (56% by random prompts and 88% by event-based reports; Table 2). Reporting of other drugs was fairly balanced between nighttime and afternoon use (Tables 1 and 2). There was variation in reporting marijuana. In-the-moment reports of marijuana were most frequently reported at night (Table 2), similar to reports of alcohol and other drugs. Based on recall, marijuana was most frequently reported in the morning (Table 1). As a similar consistency check to reporting days, we note that in-the-moment RA reports were filled out fairly evenly between the possible assessment periods of 3:00 P.M.–9:00 P.M.

3.3.4. Where. Alcohol use was most frequently reported at a friend's house, both by recall (43%; Table 1) and in the moment (32%; Table 2). Responses were more varied for marijuana and other drug use though a friend's house remained as one of the most frequently reported categories. Based on in-the-moment RA, youth were more likely to be at a friend's house during AOD use (35%) than during non-use (8%; OR = 5.97, 95% CI = 2.16–16.46).

3.3.5. Cravings. Strong cravings were more frequently reported in regards to alcohol use only versus use of marijuana or other drugs (Tables 1 and 2); a sole exception being the one report of other drug use in the moment (Table 2). Based on EoDA, daily strong cravings were higher on days when AOD use was reported (59%) versus non-use days (9%; OR = 7.34, 95% CI = 3.66–14.73). In-the-moment RA showed a similar pattern of higher reports of strong cravings during AOD use (25%) relative to non-use (10%); this difference was not statistically significant (OR = 2.99, 95% CI = 0.95–9.42).

3.3.6. Affect. Positive affect (i.e., "happiness") was the most frequently reported state by alcohol, marijuana, and other drug use, regardless of reporting today, now, or before use (Tables 1 and 2) with two exceptions. Boredom was more frequently reported for marijuana use in the moment (Table 2), but only by one additional count over happiness. Nervousness was reported for "feeling now" during one occurrence of other drug use (Table 2). The frequency of reported happiness was not very telling as happiness was the most frequently reported feeling during non-use, as captured by EoDA (64%) and in-the-moment RA (43%).

3.3.7. Reasons for use. Wanting to "get buzzed" was the most frequently reported thought before using alcohol, reported about half

the time (Tables 1 and 2). Wanting "to relax" was the most frequently reported thought for use of marijuana and other drugs, also reported about half the time.

4. Discussion

We examined CEMA by Latino youth in outpatient treatment and highlighted a number of important contextual factors related to AOD use. Better understanding context provides an immediate benefit by informing the development of general EMI content and strategies that use, for example, smartphone geo-location data to trigger in-the-moment interventions. The full capabilities of EMI can be recognized by using context (location, time) to trigger EMI with content that is appropriate for the context. For example, real-time advice delivered by EMI can differ depending on the time of day, location, and presence of peers. Social context appears to be an important contextual AOD-use factor in our study as it has in prior studies. AOD use was most frequently reported with close friends and while hanging out relative to other types of associations and activities, respectively. Alcohol by itself was more frequently reported at a friend's house while marijuana and other substances were more frequently reported at other locations. Social context has traditionally been self-reported and in turn, difficult to harness in automated applications. However, there are promising developments in providing passive mobile data streams. Many users access social networking sites through their phones that leave digital footprints of social interactions. Phone logs are also recorded and can be accessed as other researchers have done (Comulada, 2014). Social network information can be further refined by combining it with GPS location traces to determine time spent with friends at one of their homes.

In our study, AOD use was more frequently reported in the afternoon and nighttime and about half the time on weekends. This is in line with other studies that have found AOD use to be more common after school hours and on weekends (Goncy and Mrug, 2013). Alcohol consumption by itself was more frequently reported at night and on weekends relative to marijuana and other substances and warrants closer examination in larger samples. Temporal information provides a good starting point for actionable EMI information. Date and time stamps can be passively collected without user burden and provide quantifiable information, such as weekend or weekday categories, that can be incorporated into classifiers that trigger EMI.

Cravings provided useful self-reported data, with strong cravings more frequently reported on AOD use days. Cravings can be categorized in a binary fashion with reporting operationalized as a button on a phone's desktop for easy access and more frequent reporting. Random prompts can be used throughout the day to query cravings similar to Piasecki et al. (2014). This offers an improvement over our study design in the ability to better understand temporal context for AOD use. Affective states are multi-faceted and more difficult to quantify. Happiness tended to be the most frequently reported affective state across CEMA strategies, but were reported to the same degree when AOD use did and did not occur. Thoughts of wanting to get buzzed were more common for alcohol use alone and thoughts of relaxation were more common for marijuana and other substances.

Reports of context, cravings and affect were robust to CEMA reporting strategy, whether reports were based on recall or in the moment. An exception was that marijuana use was most commonly reported in the morning based on recall and only reported in the afternoon based on EBA. In-the-moment RA does not provide a comparison as youth were not prompted in the morning. Further study is needed to see if time-of-day differences in reporting marijuana hold in larger samples. Overall robustness in reporting context is encouraging and suggests that there is flexibility in using different CEMA strategies. Flexibility in assessment is important with youth in consideration of school activities and other events that may make it difficult to implement one assessment strategy.

Next steps call for studies with larger sample sizes to examine overlap between contextual factors and explore temporal relationships with AOD use, similar to multilevel analyses by Piasecki et al. (2014) that analyzed nicotine use in mostly white youth. The small number of participants, low rates of AOD use, and missing data due to nonresponse made this impractical in our study and are limitations. This hampered our ability to provide subgroup analyses by age and gender; both characteristics are linked to AOD use and context (Goncy and Mrug, 2013). There is variation in the degree of AOD use across participants that may also relate to context but was impractical to explore in our sample. Caution is also warranted in generalizing our findings for normative samples of AOD users as participants were in a substance abuse treatment program. Lastly, RA occurred once a day after school hours and more closely mimicked EoDA than true RA that typically occurs multiple times a day. Our assessment scheme limited our ability to address the second hypothesis and explore if different assessment methods elicited different types of AOD use-related context.

Notwithstanding sample size limitations, our sample is representative of Latino youth in outpatient treatment. We did not see evidence of self-selection to participate in our study; there was a lot of interest to participate. The use of a study phone and free cell phone minutes that accompanied participation provided strong incentives. Enrollment was limited by the number of study phones. Interest in our study highlights an important opportunity to develop substance use interventions for youth through a medium they already use in their daily lives.

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Contributors

WSC is responsible for the conceptual development of the manuscript and analyses. NW is responsible for the study implementation. All authors (WSC, DS, NW) contributed to the writing of the manuscript and the interpretation of results. All authors have read this manuscript and approve its submission to the journal of *Drug and Alcohol Dependence*.

Conflict of interest

The authors have no conflicts of interests to declare.

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