

Ecological Momentary Assessment of Alcohol Consumption

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Drinking Restraint and the Regulation of Alcohol Intake

The drinking restraint model suggests that excessive/binge drinking occurs in a cognitive context in which the individual alternates between being attracted to alcohol and being concerned about the need to restrict/regulate alcohol intake (Bensley, 1991; Collins, 1993). Some “restrained drinkers” may be so preoccupied with the need to lessen or control their alcohol intake that they invoke rules and set limits on alcohol use (Collins, 1993; Ruderman & McKirnan, 1984). Paradoxically, the thinking about the need to limit/regulate alcohol intake, while not being successful at such regulation, can precipitate excessive drinking (Collins & Lapp, 1991; Marlatt, 1985). In this way, drinking restraint may be a risk factor for excessive drinking and alcohol-related problems (Bensley, Kuna, & Steele, 1990; Collins, 1993; Connor, Young, Williams, & Ricciardelli, 2000; Connors, Collins, Dermen, & Koutsky, 1998; Curry, Southwick, & Steele, 1987).

Drinking Restraint, the Limit Violation Effect, and Excessive Drinking

We propose that the Limit Violation Effect (LVE) describes the process that moves restrained drinkers to engage in excessive drinking (Collins & Lapp, 1991, 1992; Collins, Lapp, & Izzo, 1994). The LVE, which is based on Marlatt and Gordon’s (Marlatt, 1985; Marlatt & Gordon, 1980) Abstinence Violation Effect, involves a cycle of limit setting, limit violation, self-blame, negative affective reactions, and excessive drinking. It provides the conceptual framework for our use of Ecological Momentary Assessment (EMA) to examine social drinkers’ risk for excessive drinking and alcohol-related problems. We proposed that restrained social drinkers regard consuming more than a predetermined amount of alcohol

as a personal failure. If they violate their limits on drinking and then blame themselves for the violations, they subsequently experience negative affective reactions such as guilt, anger, and sadness. They continue to drink (i.e., excessively) to alleviate the negative emotions they feel as a result of this self-blame.

Equivocal Evidence of the Occurrence of the LVE

Although the LVE was conceptually compelling, evidence regarding its occurrence in alcohol use has not been conclusive. In a cross-sectional questionnaire study Collins and Lapp (1991) found that perceived difficulty in controlling drinking (one aspect of drinking restraint) and self-blame for negative drinking-related outcomes predicted alcohol problems in a sample of social drinkers. However, the cross-sectional data meant that the causal linkages in the LVE model could not be directly tested.

Laboratory experiments offered a better opportunity to test the LVE but still had limitations. In the earliest such experiments, participants were given a preload of wine (to precipitate a violation) and then were offered the opportunity to drink more during a subsequent taste-rating task (Bensley et al., 1990; Ruderman & McKirnan, 1984). These experiments generally failed to produce the LVE, possibly because the experimental designs ignored the participants' need to take responsibility for the violation (Collins & Lapp, 1991) and because of the relatively short duration of time. To address the first limitation, Collins and Lapp (1991) conducted an experiment in which they maintained the possibility that participants could blame themselves for violating their drinking limits. Their procedure produced limit violations to which participants reacted with negative affect, particularly anger. However, the participants did not continue to drink, thereby showing the excessive drinking predicted by the LVE. This possibly was because they could attribute their alcohol intake to the experimental situation rather than to themselves and the relatively short (30 minutes) drinking period. The inconsistent findings about the occurrence of the LVE made it impossible to draw any firm conclusions. However, the LVE's potential importance as an explanatory model of excessive drinking provided the impetus to find new methods that could better capture its components.

Rationale for a Real-Time Momentary Approach to Data Collection

EMA Provides a Valid Method for Field Testing the LVE

To provide valid tests of predictions derived from the LVE, we needed a methodology with which to self-monitor drinking behavior and ever-changing subjective experiences (e.g., moods) in real time within and across episodes of drinking. The resulting data could be used to examine the complex relationships among subjective reactions and drinking. Traditionally, self-monitoring of alcohol use has

relied on paper-and-pencil reports (e.g., daily diaries, calendars; Samo, Tucker, & Vuchinich, 1989; Sobell, Bogardis, Schuller, et al., 1989; Vuchinich, Tucker, & Harllee, 1988). Although these self-reports allowed researchers to capture subjective states and ongoing behavior, paper-and-pencil methods had limitations that were not easily addressed. These included poor or faked compliance and deficient data (e.g., missing data, ambiguous responses; Broderick, Schwartz, Shiffman, et al., 2003; Litt, Cooney, & Morse, 1998; Stone, Shiffman, Schwartz, et al., 2002).

EMA provided the methodology of choice for examining the occurrence of the LVE. It allowed us to assess the subjective precursors of drinking (e.g., mood), alcohol intake (e.g., number of drinks), reactions to drinking (e.g., mood, self-blame), as well as subsequent drinking either proximal to (next drinking episode) and/or distal to (over days or weeks) a specific episode of drinking and limit violation. We also could collect base rate data (e.g., on mood) as a context for understanding assessments linked to specific drinking episodes. Using EMA also enhanced the validity of self-reports of subjective states and drinking behavior (Stone & Shiffman, 1994). This enhanced validity is related to the advantages of EMA. They include (1) compliance with self-monitoring cannot be faked because each entry is tagged with a time and date; (2) compliance can be tracked because failures to respond to prompts are tagged and stored; and (3) once initiated, participants must complete a standard interview, thereby providing quality control of data (Shiffman, 2000). Finally, collecting EMA data on alcohol use generated little reactivity, even among alcoholics (Litt et al., 1998).

Method

In this chapter we describe three studies in which we have used EMA methods to collect data (see Collins, Morsheimer, Shiffman, et al., 1998; Muraven, Collins, Morsheimer, et al., 2005 *a, b*; Muraven, Collins, Shiffman, & Paty, 2005). Each study focused on social drinkers who used electronic diaries (EDs) to self-monitor drinking behavior and its antecedents and consequences, as well as their activities, locations, and social contexts. The studies typically involved a session in which participants completed questionnaires, followed by a training session in which they learned how to use the ED. These two sessions were followed by weekly individual sessions to download data, receive feedback on the use of the ED, and change batteries. Our screening procedures helped to ensure that participants were willing and able to use the ED. Thus, we were able to achieve relatively good compliance with ED procedures. Table 10-1 gives information on demographics and the EMA study characteristics.

Samples

Our research focused on the LVE as a risk factor for excessive drinking and alcohol problems. We used newspaper advertisements and flyers to recruit participants from the broader community and from colleges. Typically, participants had to meet

Table 10-1. Demographic and EMA study characteristics

	Collins et al., 1998	Muraven et al., 2005	Muraven et al., 2005a		Muraven et al., 2005b
			Study 1	Study 2	
SAMPLE (<i>n</i>)	37	106	106	38	38
Men	22	49	49	20	20
Women	15	57	57	18	18
ETHNICITY (%)					
European American	89	86	86	82	82
Minority	11	14	14	18	18
MARITAL STATUS (%)					
Single	35	100	100	73.7	73.7
Other	65	0	0	26.3	26.3
Mean age (years)	35.9	19.3	19.3	26.9	26.9
Mean no. drinks/week	22	18.6	18.6	15.8	15.8
EMA platform	Psion	Palm Pilot	Palm Pilot	Psion	Psion
No. weeks of EMA	8	3	2	2	2
Intervention	Yes	No	No	No	No
Type of intervention	Behavioral				

eligibility criteria such as a willingness to drink a minimum of four drinks per week; no previous medical diagnosis or treatment for abuse of alcohol or other drugs; and no psychological, physical, medical, or legal contraindications to drinking alcohol. Table 10-1 contains information on the participants' demographic characteristics.

Momentary Data Collection

We applied EMA methods to collecting data relevant to testing the LVE, our conceptual model of risk for alcohol abuse. In our earliest studies, the ED hardware consisted of a Psion business organizer (Psion, Ltd., London, England). In later studies participants carried a Palm Pilot Professional (Palm, Inc., Milpitas, CA, USA). Each platform used software specifically developed for our projects. In each of our studies (see "Results" section), participants both initiated entries related to each episode of drinking and responded to audible random prompts to provide base rate information on the occurrence of subjective phenomena (e.g., moods) that were central to our conceptual model. Research participants were trained to interact with the ED during all of their waking hours. At night they put the ED to sleep when they went to sleep and in the morning they use the ED as their alarm clock to wake up.

The ED had a main menu from which participants could choose one of five different interviews, report a problem, suspend random prompting, and so on. The ED interviews were as follows: (1) participants initiated a morning interview when they awoke; (2) they responded to an audible random prompt (four or five times/day); (3) they initiated a "begin drinking" interview just before they started each episode of drinking; and (4) they initiated an "end drinking" interview just after they stopped drinking. In some of our more recent studies, we added a fifth daily interview called an evening report, which was scheduled to be prompted in the early evening (6 to 8 p.m.). Examples of some of the varied topics assessed in each type of interview are as follows: (1) the morning interview included the likelihood of drinking during different periods of the coming day/week; (2) the random prompt interview included positive and negative mood (to provide information on base rates); (3) the "begin drinking" interview included mood and time since drinking started (to assess compliance); (4) the "end drinking" interview included mood and the number of drinks consumed during the episode; (5) the evening report included intention to drink and plans to limit alcohol intake.

The ED software was designed to prevent missing data, out-of-range responses, and the option of abandoning (i.e., failure to complete) an interview. Response formats varied based on the type of question. Participants could use an 11-point sliding scale to make ratings, check one of many choice boxes, or select a specific number (e.g., number of drinks). To facilitate integration of the ED into everyday life and increase compliance with responding to random prompts, the software included *delay*, *suspend*, and *nap* functions. Participants could delay completing (for up to 20 minutes) a randomly prompted interview, if the prompt occurred at an inauspicious time. They could suspend (i.e., turn off) random prompting for up to 2 hours, but they were asked to indicate a reason for suspending (e.g., driving a car). They could use the *nap* function if they slept during the day (length of time unspecified).

Procedures

Eligible participants first completed a series of individual-difference measures in small groups. At the end of that session, we invited interested individuals to return to the research site for 1.5 to 2 hours of individualized training in the procedures for using the ED. In the training session, research staff used a manual to explain concepts and participants practiced with an ED until they were comfortable with the procedures. We then instructed them to use the ED to self-monitor ongoing behavior 24 hours per day for the duration of the study. An initial ED-feedback appointment took place 2 to 3 days after training. In this way, our staff could catch errors and troubleshoot problems before participants had been in the field for a long time. Feedback usually focused on problems related to compliance with the protocol or using the different features of the ED. A staff person was "on call" 24 hours each day, so participants could contact staff if they experienced an ED emergency (e.g., dead battery, software malfunction). In this way, participants who ran into trouble either could be talked through a solution or were scheduled for an immediate appointment, at which the malfunctioning ED was replaced.

DATA ANALYSES

The raw data from the ED were compiled and concatenated using a database program (Microsoft Access). Initially, we examined these tables to extract participants' compliance with the protocols and the descriptive information from the various assessments. From there, we used multilevel regression (e.g., Schwartz & Stone, 1998) to examine our hypotheses and to test our model. We focused on both the antecedents and the consequences of excessive drinking. In particular, we specified a priori relationships between excessive drinking and mood. These relationships, as fixed in our model, guided the statistical equations we tested.

In the multilevel models, we person-centered all independent variables (Kreft, de Leeuw, & Aiken, 1995; Schwartz & Stone, 1998) because our conceptual focus was on how intraindividual changes (i.e., the individual's mood at one moment compared to his or her average mood) were related to outcomes such as alcohol intake. We used hierarchical linear modeling (HLM) software (Bryl Raudenbush, & Congdon, 2000) and we examined the residuals using numeric outputs and graphs to determine whether there were any significant outliers or influential cases. We also tested whether the data violated assumptions of the analyses (Singer & Willett, 2003).

Results

Our hypotheses were well suited to EMA because they focused on how behaviors unfold over time. Rather than just examining behavior at static intervals, our primary interest was how negative affective states were dynamically related to subsequent alcohol intake. Indeed, the richness of the data allowed us to test hypotheses in several different and distinct ways and to help rule out alternative explanations. In the studies to be described, we treated alcohol intake as a continuous variable and we define heavier and lighter drinkers with reference to the mean number of drinks the sample reported consuming during a typical week (see Table 10-1

Mood Immediately after Drinking

In our first test of the IVE model, we related alcohol consumption during a drinking episode to mood after consumption (Muraven et al., 2005b). As outlined above, restrained social drinkers who blame themselves for drinking excess should experience regret over their alcohol intake. We measured mood in real time, at the start and end of a drinking episode, and related the change in mood over the course of the drinking episode to the amount consumed and attributions made immediately after drinking. From these within-person analyses we found that mood declined after episodes in which individuals consumed more alcohol than their personal average and engaged in more than average self-blame, compared to episodes in which they consumed less alcohol than average and engaged in less self-blame. Moreover, consistent with the IVE model

this effect was stronger for heavier drinkers than for lighter drinkers, suggesting that heavier drinkers were more sensitive to self-blame.

In the same study, we found that participants' mood after drinking was a predictor of how much alcohol they consumed in their next drinking episode. Consistent with the LVE, following drinking episodes in which participants felt worse than average, they returned to drinking sooner and they consumed more alcohol in their subsequent episode. This was true even after controlling for mood at the start of the next episode, time between episodes, and day of the week. Likewise, participants' self-blame for excessive drinking at the end of one episode was related to how much they consumed in the next episode. Our examination of individual differences further reinforced the predictions of the LVE model. Heavier drinkers drank more in their subsequent episode as compared to lighter drinkers, even when both groups felt equally bad after drinking. This is consistent with the theoretical prediction that negative affect should be more dysregulating to individuals who consume larger amounts of alcohol as compared to lighter drinkers (cf. Cunningham, Sobell, Sobell, et al., 1995; Greeley & Oei, 1999).

Morning after Drinking

Our finding that negative affect influences drinking during an episode was replicated for daily drinking. We examined how feelings and thoughts about drinking one day were related to actual alcohol intake the next day (Muraven et al., 2005a). Across two samples, our within-person analyses indicated that when participants felt that they violated their personal limits (measured just after the drinking episode) by drinking more than average, they experienced greater guilt the next day, even after controlling for hangover symptoms and actual amount consumed. Replicating the episode-level data, we found that the effects of limit violations on mood were stronger for heavier drinkers than for lighter drinkers in each of the two studies.

Reciprocally, guilt led to poorer self-regulation of alcohol intake; greater distress than average over alcohol consumption in the morning was linked to greater alcohol intake, higher levels of intoxication, and more limit violations later that day. Consistent with the LVE model, regret over alcohol intake on the previous day paradoxically led to more alcohol consumption that day. Finally, like the results seen when examining drinking at the episode level, these effects were stronger for individuals who drank more alcohol on average. When heavier drinkers felt guiltier than average in the morning, they consumed more alcohol that day compared to equally guilty lighter drinkers, suggesting that negative affect is more dysregulating for heavier drinkers.

Discussion

Across several levels of analyses and different samples, our use of EMA methods avoided the difficulties found in cross-sectional and laboratory studies and provided

strong support for the LVE model. As theorized in the model, we found that negative mood due to excessive drinking was associated with poorer self-regulation of subsequent alcohol intake. We examined the relationship between mood and drinking at both the day level (how drinking one day affected drinking the next day) and episode level (how mood at the end of a drinking episode was related to subsequent drinking). Individuals who drank more than they wanted, and who blamed themselves for that excessive drinking, experienced more negative affect immediately after drinking and the morning after drinking. Consistent with our model of restrained drinking and the LVE, experiencing negative affective states after drinking was dysregulating and was related to greater subsequent alcohol intake, especially for heavier drinkers.

Insights from the Real-Time Approach

To test the LVE model, it was necessary to study the unfolding of processes related to alcohol use in the real world over time. A laboratory study (Collins, Lapp, Izzo, 1994) had provided a useful first step. However, such studies were limited because of the difficulty of evoking strong emotions in an experiment, the passage of time that is needed for the LVE processes to evolve, and the changes that occur when participants drink in experimental settings (cf. George, Phillips, Skinner, 1988). The real-time EMA approach allowed us to examine the self-regulation of alcohol intake in a prospective and conceptually meaningful way. Participants regularly interacted with their EDs, thereby providing a steady flow of complex data. Indeed, we could investigate the antecedents of behavior (i.e., excessive drinking) that participants had no idea they were about to engage in, and, in fact, wished to avoid. Real-time data capture and the associated data analysis techniques helped to reduce the influence of extraneous variables and allowed for tight control over data collection. As a result, we were able to test our hypotheses in a dynamic manner that would be difficult or impossible using other data collection methods.

Another benefit of EMA data is its ideographic nature. We used a within-subject approach to analyze the antecedents and consequences of alcohol consumption. This approach helped to reduce alternative explanations for the results and permitted a strong statement on how processes occurred within a person. At the same time, the between-subjects analyses provided insight into how these processes differed between people. For example, by collecting many instances of drinking for each participant and comparing the relationship between mood and subsequent consumption across drinkers, we were able to show that negative affect was more dysregulating for heavier drinkers than for lighter drinkers. Obviously, testing such a model in a laboratory setting would be difficult, as it would require recruiting a large number of drinkers.

We had strong conceptual reasons for examining the antecedents and consequences of excessive drinking. These conceptual rationales guided our data analyses as well as the overall methodology, including how the data were collected when participants were signaled or told to initiate assessments, and the content

of the different interviews. EMA data collection minimized biases, such as memory distortions or concerns about self-presentation, while permitting tight control over data collection. The data helped us to test and develop our model and provided us with opportunities to consider and rule out alternative explanations. For example, all the analyses controlled for day of the week, to help eliminate weekly patterns of drinking such as binge drinking on the weekends. Similarly, when we examined the relationship between reporting a limit violation immediately after drinking and remorse the next morning, we controlled for previous days' alcohol intake and hangover symptoms to get a sense of the effects of limit violation on guilt, beyond the effects of acute physical symptoms or amount consumed.

Successes and Challenges

In this chapter we have described many benefits of the real-time EMA approach, most notably the success of model testing in an ecologically valid manner. In particular, the LVE model posited mechanisms that developed and changed over time and hence required testing in real-world settings. The benefits of EMA methods came with some costs and challenges, which we outline below. Although these challenges are offset by EMA's benefits, they can serve as threats to the external validity of EMA data and can create certain practical problems.

MONITORING BURDEN AND THE GENERALIZABILITY OF RESEARCH FINDINGS

An issue faced by all users of EMA is the potential burden of the frequent and intense monitoring of behavior. As a result of either self-selection related to burden or other criteria, EMA studies may be populated by unique participants who are willing to undergo the training and self-monitoring and therefore are not representative of the populations to which the researcher wishes to generalize. In our studies, some potential participants refused to interact with an ED for 24 hours each day for weeks at a time. On the other hand, many participants enjoyed interacting with their EDs and reported that it helped them to understand their behaviors and feelings and/or that it was fun and interesting.

RELLANCE ON SELF-REPORT

Despite all the strengths of EMA data, ultimately it relies on each participant's self-report. There is evidence that data collected on the computer are more valid than data collected in other ways (Corkrey & Parkinson, 2002). Yet it still would be useful to augment EMA data by collecting behavioral data, collateral reports, or biological data where possible. Although EMA's collection of prospective data enhanced our ability to make causal statements (Shiffman & Stone, 1998), our research relies on correlational analyses and lacks the control conditions that would allow for stronger statements of causality. Advances in hand-held computing may eventually allow for even more dynamic and multifaceted data collection, which could address some of these limitations.

DATA MANAGEMENT AND ANALYSES

The large amount of data generated in our EMA studies presented a challenge, and our examination of how behaviors change over time compounded that problem. In particular, separate databases containing the different assessments (i.e., morning, evening, random prompt, and before and after drinking) needed to be combined. Matching assessments required skillful manipulation of the databases. For example, selecting the random prompt closest to the beginning of a multidrinking episode was a complex, multistep process. Over time, as more sophisticated data analytic approaches (e.g., HLM) become more readily available, they will enhance researchers' abilities to handle the complex data generated using the EMA real-time approach.

PDA HARDWARE AND SOFTWARE

Our use of EMA included some practical challenges, beginning with the personal digital assistant's (PDA) hardware. In the beginning, there were frustrating losses of data because of battery failure or other malfunctions. The relatively low volume of the PDA alarm meant that we could not accommodate participant who worked in noisy environments and reported that they could not hear the random prompts. Random prompting also meant that we had to screen out participants who presented other constraints for using our software. For example, some employees had bosses who would not allow them to respond to the random prompts while at work.

We also experienced challenges specific to assessing drinking behavior. The included (1) how to define a drinking episode, (2) the pharmacological effect of alcohol on cognitive and motor performance, and (3) the drinking and sleeping patterns of our samples of young adults.

DEFINING DRINKING EPISODES

Compliance with entry of each specific drink might be burdensome, might lead to reactivity, and was not necessary to provide data for the model being tested. Therefore, we sought to facilitate self-monitoring by defining an episode of drinking as "the period of time during which you consume alcohol." We then train participants to self-define when an episode of drinking began and ended by using criteria such as change in their physical surroundings (e.g., going from drinking at home to drinking at a bar), change in activities (drinking while watching TV or drinking while eating), and the passage of time (drinking at lunch vs. dinner). This led to very large ranges in the time between episodes (e.g., 2 minutes to 1 week; Collins et al., 1998) and very large ranges in the number of episodes per participant (e.g., 5 to 58 during 8 weeks; Collins et al., 1998). Although this does not create problems for analyzing our data, it contrasted with other approaches for assessing alcohol intake. For example, Swendsen and colleagues programmed their EMA software to collect drinking data using two different forms:

(Swendsen, Tennen, Carney, et al., 2000): participants either could record each drink as it was being consumed or could initiate a program that prompted them once each hour to assess their consumption since the previous prompt 1 hour earlier. At this time, there is no standard way of defining a drinking episode or assessing alcohol intake using EMA. Current approaches need to be evaluated and new approaches need to be developed.

ALCOHOL'S EFFECTS ON COGNITIVE AND MOTOR PERFORMANCE

Imbibing large amounts of alcohol can affect cognitive and motor performance (Fillmore & Vogel Sprott, 1998). Thus, the reliability and validity of EMA data could deteriorate as a function of heavier drinking by research participants. Litt and colleagues (1998) reported that about half of their treated alcoholic sample stopped EMA recording during and after drinking. Our experience with heavier drinkers (e.g., average intake of 22 drinks/week) has not shown the same level of disruption. Collins and colleagues (1998) reported that compliance with initiating the "begin drinking" interview was somewhat better (87% within 1 minute) than compliance with initiating the "end drinking" interview (48% within 1 minute). However, some of this delay may be a function of deciding whether an episode of drinking had truly ended rather than a reflection of the slowing of cognitive and motor functions as a result of high blood-alcohol levels. Even so, researchers should continue to examine the role of the pharmacological effects of alcohol, particularly when blood-alcohol levels are very high.

IRREGULAR DRINKING AND SLEEPING PATTERNS

Many of our samples consisted of young adults whose weekend drinking episodes began around 11 p.m. and ended when the bars closed at 4 a.m. They then went to sleep at around 8 a.m. and woke up around 4 p.m. These wake and sleep patterns created problems for defining a "morning" assessment and for defining and programming a period of sleep for our software. Although we were able to address these problems, particularly during our weekly review of each participant's data printout, they clearly presented some training and interpretational challenges. These challenges may not be unique to assessing drinking, but rather may reflect issues that arise with young adult populations.

Prospects for Application of EMA Methods

We believe that EMA methods represent an important step forward in testing and building a model of alcohol use and abuse. The ability to assess internal and external phenomena as they occur over time, in an ecologically valid manner, presents researchers with the opportunity to study alcohol-related phenomena in much greater detail and to examine hypotheses that heretofore have been difficult or

nearly impossible to investigate. Indeed, EMA approaches already have been applied to the examination of other complex and dynamic models of alcohol and abuse. For example, EMA methods have been successfully applied to test the self-control strength model (Muraven, Collins, Shiffman, & Paty, 2005) and self-medication hypothesis (Swendsen et al., 2000) as they pertain to alcohol use.

Muraven, Collins, Shiffman, and Paty (2005) used EMA data to examine whether naturally occurring self-control demands were associated with drinking behavior. The assumption was that the exertion of self-control in daily life might undermine an individual's subsequent ability to use self-control to regulate alcohol intake (cf. Muraven, Collins, & Nienhaus, 2002). Consistent with self-control strength theory (Muraven & Baumeister, 2000; Muraven, Tice, & Baumeister, 1998), they found that participants who experienced greater self-control demands during the day were more likely to drink to excess that night. In addition, experiencing greater than average self-control demands led to more drinking on occasions when the individual planned to limit alcohol intake.

The self-medication hypothesis states that alcohol is used to medicate/relieve negative affective symptoms such as anxiety and depression. The experience of relief positively reinforces further drinking. Over time, regular intake of large amounts of alcohol in response to negative affective states could explain the comorbidity of alcoholism with mood and anxiety disorders. Consistent with this hypothesis, Swendsen and colleagues (2000) found that negative affect (particularly nervousness) earlier in the evening was associated with drinking later in the night. As a result of drinking, participants reported experiencing less nervousness/negative affect.

The successful use of EMA data to test different conceptual models of alcohol use is only the beginning. The EMA method could easily be applied to clinical contexts to monitor alcohol use and related symptoms during different phases of treatment (cf. Collins et al., 1998). This ongoing self-monitoring could be useful for many different alcohol treatments, including pharmaceutical and/or behavioral interventions. Real-time EMA methods could be applied to assessing change in symptoms as well as physical and psychological side effects of treatment. In the context of cognitive-behavioral treatment, the flexibility of EMA software makes it possible to develop interactive programs that include suggestions for using specific strategies and/or reminders of goals/outcomes that the individual wants to achieve. The only limits are those imposed by the imagination of the researcher/clinician as well as the hardware and software.

In the future, the platform on which EMA data is collected will likely expand beyond PDAs. Although we pioneered the use of hand-held computers to collect EMA data on drinking and related phenomena (Collins et al., 1998), and although many benefits to using PDAs, we also became aware of limitations related to storing data and incorporating the technology into the participants' daily lives. Thus, we explored the use of cellular telephones and interactive voice response (IVR) technology as an alternative, more convenient and cost-effective method for collecting EMA data from social drinkers (Collins, Kashdan, & Gollnisch, 2003). For this cellular monitoring, we used a data collection format similar to what we had used with PDAs. Using IVR, we verbally presented our interviews and used a multiple-choice

response format, to which the participant responded by pressing a number on the telephone keypad. Participants carried the cellular telephones at all times and when appropriate (either in response to a random prompt or to initiate an interview) used them to call the IVR software on a central computer. The combination of IVR and cellular phones provided participants with the mobility and flexibility to self-monitor in almost any context. Participants were compliant in their use of cellular monitoring, and we found few differences in consumer satisfaction as compared to traditional paper-and-pencil monitoring.

Relative to data collection on PDAs, the benefits of using cellular telephones included the following: (1) pervasive knowledge and use of cellular telephones that lessened the amount of training needed and made it easier to integrate data collection into the participant's daily life; (2) instantaneous entry of data into a central database, thereby limiting data loss and enhancing data storage; (3) the possibility of ongoing monitoring of compliance with the research protocol so as to provide participants with more immediate feedback; and (4) lower software, hardware, and data management costs. These features and benefits provided an alternative to PDAs and expanded upon previous use of IVR and home telephones to collect daily reports of drinking (cf. Searles, Helzer, Rose, & Badger, 2002; Searles, Helzer, & Walter, 2000).

Changes in PDAs and cellular telephones promise many exciting possibilities for the future hardware used to collect EMA data. Recent advances in memory technology (e.g., flash memory) may help forestall data losses from PDAs. It now is possible to present cellular monitoring in text as well as audio formats. Participants can use picture telephones to provide detailed information on their location and/or social context. Who knows what will be possible in a few years? These and other technological advancements will enhance the ability to use EMA methods to reach target populations in real-world contexts and to examine dynamic process related to alcohol use and related behaviors over time.

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