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## Diaries for Observation or Intervention of Health Behaviors: Factors that Predict Reactivity in a Sexual Diary Study of Men Who Have Sex with Men

Michael E. Newcomb\* and Brian Mustanski

Department of Medical Social Sciences, Northwestern University Feinberg School of Medicine, Chicago, IL

### Abstract

**Background**—Behavioral diaries for observation of health-related behaviors assume absence of reactivity (i.e., change in behavior resulting from observation), while self-monitoring diaries maximize reactivity for behavior change. Little is known about when and for whom behavioral diary studies become self-monitoring interventions.

**Purpose**—This study evaluated the moderating effects of social cognitive variables on reactivity in sexual risk behavior and risk appraisals in a diary study of men who have sex with men (MSM).

**Methods**—143 MSM completed weekly online sexual diaries for three months. Analyses were conducted with Hierarchical Linear Modeling.

**Results**—There was no evidence of reactivity for the sample as a whole. Social cognitive variables (e.g., risk reduction motivation, condom use intentions, and social norms) moderated reactivity in study outcomes. For example, more highly motivated MSM experienced declines in serodiscordant unprotected anal intercourse over time.

**Conclusions**—Effectiveness of behavioral self-monitoring strategies may vary depending on social cognitive domains.

### Keywords

behavioral diaries; self-monitoring; health behavior; sexual risk; HIV/AIDS; men who have sex with men

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Behavioral diaries are widely-used as a method for observing health-related behaviors, and this approach has been implemented to identify predictors and correlates of myriad health related outcomes (1). In addition to their use as a survey methodology, behavioral diaries are frequently used in clinical interventions as self-monitoring tools for health-behavior change (2-4). In fact, a Pew Research Poll conducted in 2012 reported that 69% of adults in the United States track at least one health related behavior (5). However, while the

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\* corresponding author: Michael E. Newcomb, Ph.D., Department of Medical Social Sciences, Northwestern University, Feinberg School of Medicine, 625 N. Michigan Ave., Suite 2700, Chicago, IL 60611, Phone: 312-503-0702, Fax: 312-503-4800, newcomb@northwestern.edu.

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implementation of behavioral diaries as either an observational or intervention tool is analogous, observational and self-monitoring paradigms make opposing assumptions. Observational diary studies assume an absence of participant reactivity (i.e., systematic change in responding resulting from repeated assessment), while diaries as self-monitoring tools attempt to maximize reactivity and assume that participants will change their behavior through the act of observation. There has been a dearth of research testing these assumptions, and it remains unclear when and for whom behavioral diary studies become self-monitoring interventions.

Behavioral diaries have been utilized to observe prospective engagement in a variety of health behaviors and outcomes, including medication adherence and compliance (6, 7), disease symptom management (8, 9), diet and food intake (10, 11), dimensions of affect (12-15), substance use (16-18), and sexual behavior (13, 14, 19-22). Several variations of this methodology, including daily and weekly diaries, have been described in the literature with follow-up periods of various durations (e.g., one month to six months) (22, 23). Research has suggested that prospective behavioral diaries may be more accurate than retrospective surveys in estimating frequency and patterns of health-related behaviors, particularly when there is substantial within-persons variability in the outcome of interest (23, 24). The increasing ubiquity of the Internet in the 21<sup>st</sup> century has allowed researchers to conduct behavioral diary studies entirely online, which has greatly improved the efficiency of this design and reduced participant burden (1, 23). The issue of minimizing participant reactivity is critical in using this methodology to observe behavior, and numerous studies have tested for systematic increases or decreases in behaviors over the course of the diary completion period (e.g., 19, 22, 25, 26). Most of these studies have found that behavioral reactivity during the assessment period is negligible. In fact, studies have found little evidence for reactivity in methodologies that administer assessments even more frequently than daily diaries (27), such as ecological momentary assessment (28). However, these approaches only study sample-wide effects of reactivity, and with such analyses a null result could represent a combination of some participants increasing their behaviors over time while others showing decreases. To our knowledge, no studies have explored moderators of reactivity in diary studies.

Behavioral diaries have frequently been used to study predictors and correlates of sexual risk behavior in men who have sex with men (MSM) (22, 23), a population that is substantially impacted by HIV/AIDS in the United States (29, 30). Sexual behavior diaries have been found to more accurately estimate frequency of condom use than retrospective surveys (23, 24), and this methodology has helped to shed light on mixed findings for the association between various risk factors and unprotected sex (e.g., alcohol use and online partner seeking) (31-33). A recent study investigated reactivity in sexual risk behavior among MSM enrolled in a web-based sexual behavior diary study (22). In this study, participants in a no diary control condition increased their number of unprotected anal sex acts during the study relative to participants completing sexual behavior diaries. However, more research is needed to determine whether certain MSM are more likely to experience reactivity than others and whether these MSM actually show reductions in sexual risk behavior over time, which would suggest that diaries may be a viable tool for promoting behavior change. If sexual behavior diaries do in fact facilitate reductions in sexual risk behavior, this

methodology could provide a low cost and efficient means to reduce risk of HIV infection in this at-risk population.

Behavioral self-monitoring strategies are also frequently used in clinical interventions to produce health-behavior change (e.g., behavioral weight loss). Social Cognitive Theory of self-regulation (34) describes the process by which individuals monitor their behavior over time for the purpose of enacting and maintaining behavior change. Self-regulation is dependent upon self-monitoring, including the fidelity, consistency and proximity of self-monitoring to the target behavior. Applied to HIV risk behavior, Fisher and Fisher's (35) Information, Motivation and Behavioral Skills (IMB) Model integrates aspects of Social Cognitive Theory (36) and Theory of Reasoned Action (37) to describe the social cognitive processes that influence HIV preventive behaviors. The IMB Model asserts that the fundamental determinants of engaging in HIV preventive behaviors are the combined effects of having HIV-related information and prevention knowledge, motivation to reduce risk, and behavioral skills to engage in preventive behaviors. Moreover, multiple factors influence motivation to reduce sexual risk, including intentions to use condoms during sexual encounters, social norms of condom use, appraisals of the degree of risk associated with unprotected sex, and the perceived severity of the consequences of sexual risk. Finally, the IMB Model discusses the importance of sexual risk-reduction skills, which have typically been measured in the literature as condom use self-efficacy (e.g., 38). Individuals must possess the belief that they are capable of drawing on their knowledge and utilizing risk reduction skills in multiple contexts in order to consistently engage these skills. As such, it is possible that simple observation of behavior may not be sufficient for individuals to engage in behavior change without the presence of social cognitive processes that would promote behavior change during self-monitoring.

In order for behavioral diaries to be utilized as effective observational tools, one must limit the effect of reactivity on behavior. On the other hand, self-monitoring tools that promote health-behavior change attempt to maximize reactivity to reduce problem behaviors. A critically important, and often overlooked, consideration in assessing behavior change in observational and self-monitoring studies is the manner in which researchers frame study goals to participants. For example, describing a study as a self-monitoring intervention may elicit the expectation in participants that the target behavior will or should change. Unfortunately, manuscripts most often do not report how studies were framed for participants, which renders it difficult to assess this possibility. In terms of sexual risk behavior, it remains unknown at what point sexual behavior diaries cease to be an observational tool and become a self-monitoring intervention strategy. Despite calls to examine the utility of self-monitoring and diary approaches to change sexual risk behavior in MSM (39), this approach has been under-utilized to date. Furthermore, little is known about the factors that influence successful sexual risk behavior change during self-monitoring in this population, including whether individuals with certain characteristics are more successful than others.

The current investigation aimed to: 1) examine whether sexual risk behavior (i.e., unprotected anal intercourse (UAI) and serodiscordant UAI) and risk appraisals changed systematically over the course of a three-month weekly diary study (i.e., participant

reactivity); and 2) investigate whether social cognitive processes moderated reactivity in behavior and risk appraisals over time. In accordance with previous research, we hypothesized that there would not be evidence of reactivity in responding for the sample as a whole. Based on Social Cognitive Theory (36) and the IMB Model (35), we hypothesized that MSM who had more HIV knowledge, were higher in risk reduction motivation, had stronger condom use intentions, had more supportive norms of condom use, reported higher perceived severity of HIV infection and had higher self-efficacy would show a larger decrease in reported sexual risk, and a larger increase in risk appraisals (i.e., perceived risk of sexual encounters), over time compared to those with lower scores on each of these constructs. While these hypotheses are specific to HIV risk behaviors, our examination of social cognitive factors as moderators of reactivity has broad implications for the use of diaries for monitoring and changing behaviors in many domains of behavioral medicine.

## Methods

### Participants

One hundred forty-three ethnically diverse MSM were enrolled in a prospective diary study of sexual behavior. The mean age of the sample was 27.53 ( $SD = 7.33$ ) with an age range of 16-40 years. At the time of enrollment, 9.1% were under age 18. Six participants did not report any sexual behavior during the 12-week assessment period, leaving an analytic sample of 137 MSM. There were no significant differences between the full and analytic samples on any of the measured demographic characteristics. See Table 1 for full demographic description of the sample.

### Procedures and Design

Participants were recruited online via advertisements posted on Craigslist and Facebook. Inclusion criteria were: (1) oral/anal sex with a man during the previous 6 months, (2) between the ages of 16 and 40 years, (3) not in a sexually monogamous relationship, and (4) HIV-negative or unknown serostatus. Inclusion criteria were utilized to increase the likelihood that participants would have multiple sexual encounters/partners during the assessment period and to examine risk factors for sexual risk behavior from a primary prevention perspective in the developmental and racial groups that are currently at highest risk for HIV acquisition. The protocol was approved by the Institutional Review Board (IRB) with a waiver of parental permission under 45 CFR 46.408(c) for participants aged 16–17 (for more information on relevant IRB issues in conducting research with sexual minority minors, see 40). All participants were provided with an information sheet that detailed key information regarding research subjects' rights and issues related to confidentiality. Capacity of minor participants to assent was determined by administering four multiple choice questions based on this information during the eligibility screener that evaluated participants' ability to: (1) name things they would be expected to do during the study, (2) explain what they would do if they no longer wished to participate in the study, (3) explain what they would do if they experienced distress during the study, and (4) identify potential risks for participating in the study (41, 42).

Participants were told that the purpose of the study was to learn more about factors that put men at risk for HIV (i.e., an observational study rather than a self-monitoring intervention). Participants completed baseline measures of between-subjects variables (i.e., demographics and social cognitive variables) before beginning weekly sexual behavior diaries. Weekly diaries were completed for 12 weeks. Each diary survey detailed the specific activities of up to three sexual encounters from the previous week and situational variables associated with these encounters (e.g., partner and relationship characteristics). Participants received email reminders each week and had 48 hours to complete each diary. All questionnaires were completed online. Participants were paid up to 60 dollars for participation, pro-rated for participation level. On average, participants completed 83.7% of all diary surveys. To avoid multiple enrollment of the same participant, contact information was cross-referenced against: date of birth, age, race/ethnicity, geographic location, additional contact information, and IP address. Online advertisements and the eligibility screener did not indicate the necessary requirements for eligibility in order to minimize the potential for faking eligibility (43).

## Measures

**General Demographics**—The demographic questionnaire assessed participants' age, race/ethnicity, self-reported sexual orientation, and geographic location.

**HIV/AIDS Knowledge Questionnaire (HIV-KQ-18; 44)**—The HIV-KQ-18 is an 18-item true-false self-report instrument assessing knowledge of transmission and prevention. It demonstrates strong internal consistency, test-retest stability, and correlations with other measures of HIV knowledge. The HIV-KQ-18 has been successfully used with young adults (45) and MSM (46). Four additional items were added to assess MSM-specific HIV knowledge, and example items included, “A person cannot get HIV from having sex with someone who is HIV-positive but has an undetectable viral load” and “A person cannot get HIV from being the ‘top’ or insertive partner during anal sex.” Cronbach's  $\alpha$  in this sample (including additional items) was .73 and the mean number correct was 17.80 ( $SD = 3.12$ ), or 81% correct on average with a standard deviation of 14%.

**HIV/AIDS Motivation and Behavioral Skills (38)**—This is a 17-item self-report measure that assessed: Motivation (i.e., intentions to use condoms, risk reduction motivation), Social Norms (i.e., partners', friends', and family members' opinions about condom use), and Behavioral Skills (i.e., condom use self-efficacy). Three additional questions were added to assess perceived severity/consequences of becoming infected with HIV (e.g., “How concerned would you be about your future if you became HIV positive?”). Internal reliabilities of these sub-scales ranged from .57 to .91 (Cronbach's  $\alpha$ : Intentions = .91, Social Norms = .69, Self-Efficacy = .85, and Perceived Severity = .57). Risk reduction motivation was assessed with a single item: “How would you describe your motivation to become safer/stay safe?” Components of the HIV/AIDS Motivation and Behavioral Skills measure were analyzed as separate constructs, as evidence suggests that they may contribute uniquely to HIV risk (38). Higher scores on each component reflected: higher risk reduction motivation, stronger intentions to use condoms, more supportive social norms for condom use, and higher perceived severity of infection.

**Sexual Behavior**—Each week participants reported the number of sex partners they had during the previous week. Participants reported on specific sexual behaviors (e.g., oral and anal sex) that occurred during each of up to three sexual encounters (i.e., the three most recent sexual encounters) and whether or not a condom was used for each behavior. We calculated two dichotomous risk variables for analyses: 1) unprotected anal intercourse with a male partner (UAI; coded 1) versus protected anal intercourse and/or any oral sex with a male partner (protected or unprotected; coded 0); and 2) UAI with an HIV-positive or serostatus unknown male partner (serodiscordant UAI; coded 1) versus UAI with an HIV-negative male partner, protected anal intercourse with partners of any serostatus, and/or any oral sex (protected or unprotected; coded 0). All other sexual encounters were excluded from analyses.

**Risk Appraisals**—For each sexual encounter reported in weekly diaries, participants evaluate the riskiness of these encounters using the following question: In terms of risk for HIV, how risky do you think this sexual encounter was?" Participants responded on a 4-point Likert scale (0 = not risky, 1 = somewhat risky, 2 = risky, and 3 = very risky).

## Analyses

All analyses were conducted using Hierarchical Linear Modeling (HLM) 7.0 statistical software (47). HLM is well-suited to analyze behavioral diary data because it is designed to account for dependency in observations in data that contains a nested or multilevel structure and therefore does not assume independence of observations. In this case, sexual encounters (Level 1) were nested within participants (Level 2). At Level 1, HLM estimated change over time (i.e., reactivity) in the outcome variables (i.e., UAI, serodiscordant UAI, and risk appraisals) by entering week of data collection as a Level 1 main effect. At Level 2, between-subjects characteristics can be evaluated as moderators of Level 1 effects. In these analyses, we examined the moderating effects of social cognitive variables on reactivity (i.e., change in UAI, serodiscordant UAI, and risk appraisals over time).

Maximum likelihood estimation was used to model all outcome variables. A Bernoulli distribution was used in estimating the dichotomous outcomes (i.e., UAI and serodiscordant UAI), which accounted for over-dispersion (i.e., the standard deviation of the outcome variable is larger than the mean). Results are presented as odds ratios (OR). A normal distribution was used in estimating the continuous outcome variable (i.e., risk appraisals), and results are presented as standardized coefficients. The HLM models made use of all available data. Robust standard errors were used in estimating significance for all effects.

## Results

Participants had approximately one sexual encounter per week ( $M = 0.94$ ,  $SD = 1.26$ ; range 0–15) and a total of 1,189 episodes observed in the data, 88.2% of which occurred with male partners. 4.2% of participants reported having more than three encounters during any given week, meaning these analyses captured the majority of participants' encounters during the assessment period. Across all participants, 22% of reported sexual encounters with male partners were UAI episodes, and 9% were UAI episodes with HIV-positive or serostatus unknown male partners. Weighted Kappa was 0.18 for UAI, indicating that participants

were largely inconsistent in their UAI behaviors across episodes. Conversely, weighted Kappa for serodiscordant UAI was 0.94, indicating that participants were largely consistent in their serodiscordant UAI behaviors. The intraclass correlation coefficient (ICC) for risk appraisals was 0.58, indicating that 58% of the variance in risk appraisals was due to individual differences and 42% was due to event-level factors. Further details on predictors of sexual risk behavior and risk appraisals in this sample, including sexual partner characteristics, substance use, cognitive influences, and differences by race, are reported elsewhere (19, 32, 48).

### **Reactivity in Unprotected Anal Intercourse**

We first tested for reactivity (i.e., behavior change due to study participation) for the sample as a whole by entering the week of data collection as a Level 1 variable. The results did not support reactivity in responding for UAI (OR = 0.98, 95% CI = 0.93 – 1.03). Next, each social cognitive variable was entered at Level 2 as a moderator of week of data collection to examine group differences in reactivity in UAI (see Table 2), and all analyses were conducted while adjusting for the main effects of social cognitive variables. The main effects of social cognitive variables on sexual risk outcomes are reported elsewhere (48), and condom use self-efficacy was the only variable that had a significant main effect on UAI. In terms of the influence of social cognitive variables on reactivity, condom use intentions moderated the association between week of data collection and odds of UAI, such that MSM with lower condom use intentions at baseline experienced a more rapid decrease in odds of UAI compared to those with higher intentions (see Figure 1; OR = 1.11, 95% CI = 1.00 – 1.22). Risk reduction motivation also moderated the association between week of data collection and odds of UAI at the trend level (OR = 0.93, 95% CI = 0.86 – 1.01), such that MSM with more risk reduction motivation experienced a marginally more rapid decline in odds of UAI compared to those with less motivation. The following social cognitive variables were not significant moderators of the association between week of data collection and odds of UAI: HIV knowledge, perceived severity of infection, condom use self-efficacy, and social norms of condom use.

### **Reactivity in Serodiscordant Unprotected Anal Intercourse**

The current analyses did not support reactivity in responding for serodiscordant UAI (OR = 0.99, 95% CI = 0.92 – 1.06). Again, each social cognitive variable was entered at Level 2 as a moderator of week of data collection to examine group differences in reactivity in serodiscordant UAI (see Table 2). All analyses adjusted for the main effects of social cognitive variables. Risk reduction motivation was a significant moderator of the association between week of data collection and odds of serodiscordant UAI (see Figure 1; OR = .94, 95% CI = 0.89 – 0.99). MSM with more risk reduction motivation experienced a significantly steeper decline in odds of serodiscordant UAI compared to those with less motivation. No other social cognitive variables were significant moderators of reactivity in serodiscordant UAI.

## Reactivity in Risk Appraisals

The current analyses did not support reactivity in responding for risk appraisals (coefficient = 0.001,  $p = .916$ ). We conducted two analyses to examine the influence of social cognitive variables on reactivity in risk appraisals (see Table 3). First, we examined social cognitive variables as moderators of week of data collection, while adjusting for the main effects of social cognitive variables and UAI. Social norms of condom use moderated the association between week of data collection and risk appraisals (see Figure 1; coefficient = .04,  $p < .05$ ), such that MSM with more supportive social norms experienced an increase in perceived riskiness of their sexual encounters compared to those with less supportive social norms. No other social cognitive variables were significant moderators of this effect. Next, we entered a variable denoting the interaction between week of data collection and UAI into Level 1. Social cognitive variables were entered as moderators of this interaction term in order to examine whether social cognitive variables influenced change in risk appraisals over time when MSM were actually engaging in UAI (i.e., three-way interaction). These analyses revealed a three-way interaction between risk reduction motivation, week of data collection, and UAI in describing risk appraisals (see Figure 1; coefficient = -.06,  $p < .05$ ). In other words, MSM who had less risk reduction motivation at baseline experienced a sharper increase in perceived risk of their actual UAI encounters compared to those with higher motivation at baseline. There was no apparent change in perceived risk over time for MSM engaging in non-risk episodes. No other three-way interactions were significant.

## Discussion

The current study found that while the sample as a whole did not show evidence of reactivity during the three-month sexual behavior diary study, individuals with varying levels of certain social cognitive variables showed reductions in sexual risk behavior over time, as well as increases in perceived risk of their sexual encounters. More specifically, MSM with lower initial levels of condom use intentions experienced greater declines in odds of UAI, whereas MSM with higher risk reduction motivation experienced declines in odds of serodiscordant UAI. In terms of risk appraisals, MSM with more supportive social norms of condom use experienced increases in perceived risk. Furthermore, MSM with lower initial levels of risk reduction motivation experienced greater increases in perceived risk when actually engaging in UAI (i.e., three-way interaction) compared to those with higher motivation or those not engaging in sexual risk.

These findings indicate that testing for reactivity in the sample as a whole may not be sufficient in examining whether observational studies result in behavior change, and more nuanced moderating analyses can uncover important subgroup differences in behavior change. Our study has important implications for future research using behavioral diaries in observational studies. If evidence of reactivity is found in observational studies, including reactivity that is limited to certain subgroups, studies may benefit from accounting for these changes in behavior in analyses. This may be accomplished, for example, by including the growth term (e.g., wave of data collection, participant age at each wave) and the interaction between the group difference variable and growth (in the case of subgroup differences in reactivity) as covariates in analyses to help account for the influence of these variables on



study outcomes. More attention is warranted with regard to the appropriate statistical adjustments that would help account for the presence of reactivity.

Additionally, findings suggest that behavioral self-monitoring strategies could effectively reduce sexual risk behavior in MSM, particularly if these intervention strategies address the complex ways in which social cognitive processes affect one's ability to engage in preventive behavior. For example, participants who are more highly motivated to reduce risk may develop dissonance regarding the acceptability of their own unprotected sex behaviors while reporting them in a diary. This dissonance resulting from self-monitoring may then motivate reductions in unprotected sex over time. Conversely, we observed that *less* highly motivated MSM experienced increases in perceived risk of their unprotected sex encounters while not actually decreasing engagement in these sexual risk behaviors. This suggests that self-monitoring may help less motivated individuals increase awareness of their risk behaviors, but they may need additional intervention content in order to engage in actual behavior change. Furthermore, MSM with lower condom use intentions experienced a decline in sexual risk relative to those with stronger intentions. This is counterintuitive given that Social Cognitive Theory (36) would predict that intentions would be strongly linked to motivation (35, 36), and motivation showed the opposite pattern. It may be that different social cognitive factors are differentially associated with reactivity, but this finding may also be an artifact of the data collected in this study. Further research is needed in order to evaluate whether the risk reductions we observed were actually caused by self-monitoring or whether we were simply observing the natural trajectory of individuals who were already motivated to change their behavior at the start of the study. Additionally, our study explicitly told participants that the purpose of the research was to observe factors related to HIV risk. Had we framed the study as a self-monitoring intervention we may have observed greater reductions in sexual risk.

In order to determine whether the observed reduction in sexual risk behavior is actually a result of self-monitoring, it is necessary to employ an experimental design in which participants are randomized into either a behavioral diary condition or no diary comparison group. Without research that directly compares the behavior change experienced in a diary study to a control group that does not receive diaries, it is not possible to determine whether the act of self-monitoring is at the root of this behavior change. Such an experimental design should frame the research as an observational study to participants so as to control for participant expectations of behavior change that might arise were the study to be framed as a self-monitoring intervention. Furthermore, given that the current findings indicate that some MSM may benefit from self-monitoring more than others in terms of reducing sexual risk behavior (i.e., those higher or lower on certain social cognitive domains), it is possible that other subgroup differences may exist in the ability to self-monitor (e.g., age cohort, racial differences, etc.) or that certain situational or contextual variables might impede the ability to self-monitor (e.g., substance use). Further research with a larger sample size and randomization into diary and control conditions is necessary to fully answer these questions.

Behavioral diaries have been administered on various frequency schedules (e.g., daily or weekly; 22, 23) and durations, and these factors may impact reactivity. In fact, Social Cognitive Theory states that self-monitoring for the purpose of behavior change is

dependent upon the fidelity, consistency and proximity of self-monitoring to the target behavior (49). Participant attrition in behavioral diary studies and self-monitoring interventions is also an important consideration, as observational and intervention strategies are not particularly informative or useful if they are unable to retain a sufficient amount of the sample. More research is needed to determine the ideal frequency and duration of diary administration in order to minimize participant attrition while maximizing the ability to self-monitoring and alter one's behavior.

If future experimental studies indeed find that MSM experience reactivity when enrolled in sexual behavior diary studies and reduce their sexual risk due to self-monitoring, this methodology would provide a low cost, efficient, and easily disseminable intervention strategy to reduce sexual risk behavior in this at-risk population. Moreover, this methodology may also prove to be an effective intervention strategy for various other health-related behaviors and populations. However, it may be that the simple act of self-monitoring is not enough to reduce risk behavior, and additional content may need to be provided to participants. For example, self-monitoring interventions may need to engage participants in preparatory work (i.e., motivational interviewing, skills to enhance self-efficacy) in order to maximize behavior change, which is corroborated by the current findings that certain individuals experienced increases in their perceived risk for HIV infection during the course of the study while not actually decreasing their unprotected sexual behavior. By measuring certain variables that are associated with reactivity at baseline (e.g., motivation), self-monitoring interventions may be able to determine a priori which individuals will benefit from a simple self-monitoring paradigm versus an enhanced self-monitoring intervention that includes more targeted risk reduction content.

These findings must be interpreted in the context of several important limitations. First, this study did not randomize participants into diary and control (i.e., no diary) conditions. Without a comparison group, we are unable to determine whether the change in sexual risk behavior observed in the current study was actually due to self-monitoring or was simply the result of individuals' natural trajectories of declining sexual risk. Additionally, this study utilized a convenience sample of MSM and only examined reactivity in the context of one health-related outcome (i.e., HIV risk). While these results are promising and may have broader implications beyond this population, they will need to be replicated with other groups and other health-related behaviors. Finally, there are certain limitations inherent in online recruitment and data collection. With online recruitment, multiple enrollment of participants or faking eligibility is possible. While we adhered to rigorous procedures to minimize these risks, it is not possible to fully rule out these possibilities. Additionally, all data for this study were collected online. While it is not possible to control the environments in which participants completed online assessments, evidence suggests that online data collection is just as accurate as in-person data collection, and it may be perceived as more anonymous and may reduce the effect of social desirability with self-report data (50).

These limitations notwithstanding, these novel findings have important implications for the use of behavioral diaries as both observational tools and self-monitoring interventions. While the current study examined measurement reactivity in the context of a sexual diary study of MSM, the observed patterns may generalize to other health-related behaviors and

could have a profound impact on the development of efficient and low-burden intervention strategies. The next step in determining whether these changes in risk behavior are actually a result of self-monitoring is to utilize an experimental design in which participants are randomized into behavioral diary and no diary control conditions. The information yielded from such an experiment will provide critical information with regard to the validity of behavioral diaries as observational tools, as well as the feasibility of harnessing this methodology for intervention.

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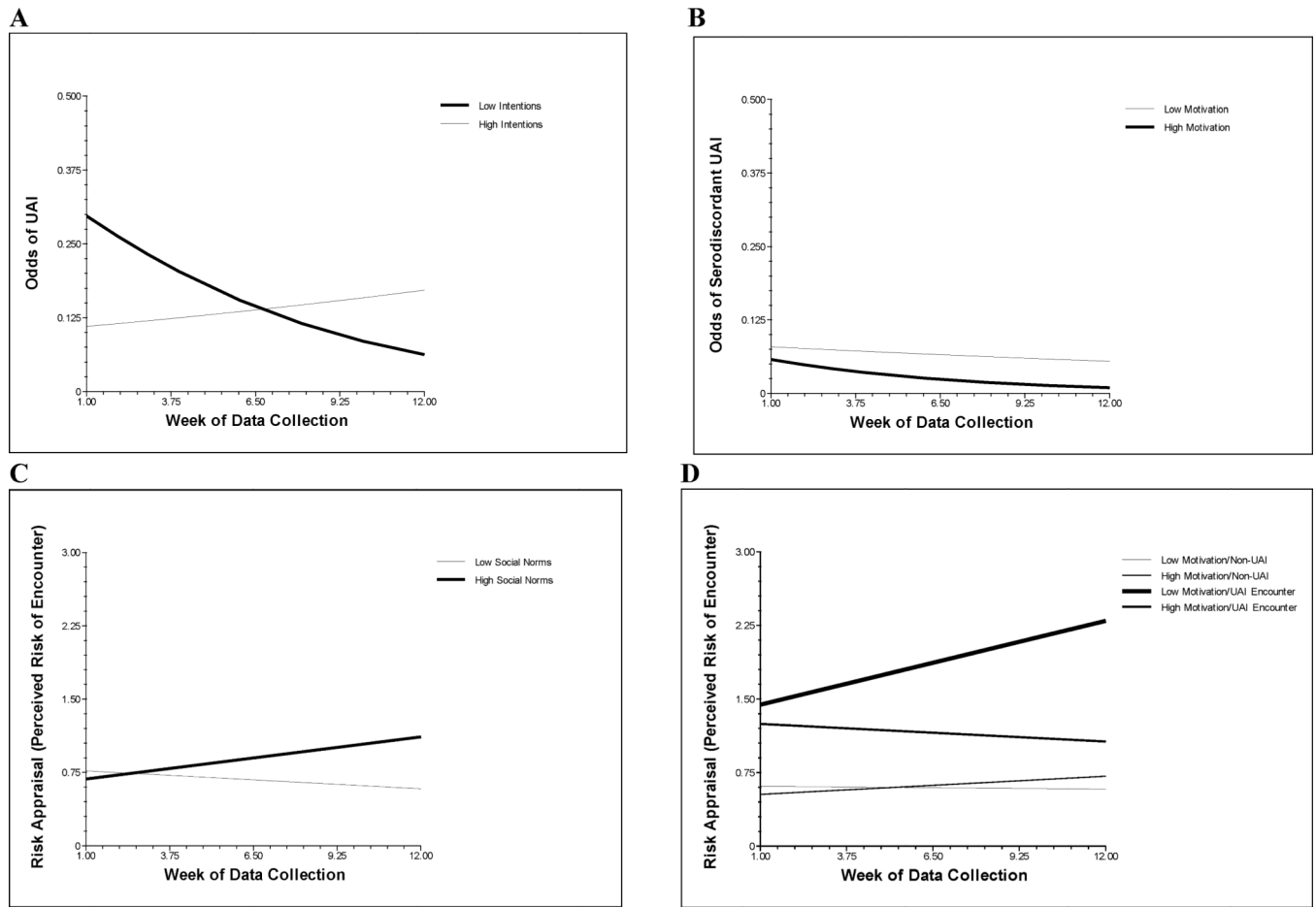
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## References

1. Bolger N, Davis A, Rafaeli E. Diary methods: capturing life as it is lived. *Annu Rev Psychol.* 2003; 54:579–616. [PubMed: 12499517]
2. Clar C, Barnard K, Cummins E, Royle P, Waugh N. Aberdeen Health Technology Assessment Group. Self-monitoring of blood glucose in type 2 diabetes: systematic review. *Health Technol Assess.* 2010; 14:1–140.
3. Glynn LG, Murphy AW, Smith SM, Schroeder K, Fahey T. Self-monitoring and other non-pharmacological interventions to improve the management of hypertension in primary care: a systematic review. *Br J Gen Pract.* 2010; 60:e476–488. [PubMed: 21144192]
4. Burke LE, Wang J, Sevick MA. Self-monitoring in weight loss: a systematic review of the literature. *J Am Diet Assoc.* 2011; 111:92–102. [PubMed: 21185970]
5. Tracking for Health. Washington, DC: Pew Research Center; 2013. Pew Internet & American Life Project.
6. Huber LR, Broel EC, Mitchelides AN, Dmochowski J, Dulin M, Scholes D. Comparison of prospective daily diaries and retrospective recall to measure oral contraceptive adherence. *Contraception.* 2013 Epub 3/15/2013.
7. Gordon EJ, Prohaska TR, Gallant MP, Siminoff LA. Adherence to immunosuppression: a prospective diary study. *Transplant Proc.* 2007; 39:3081–3085. [PubMed: 18089327]
8. Burton C, Weller D, Sharpe M. Are electronic diaries useful for symptoms research? A systematic review. *J Psychosom Res.* 2007; 62:553–561. [PubMed: 17467410]
9. Given J, O'Kane M, Bunting B, Coates V. Comparing patient-generated blood glucose diary records with meter memory in diabetes: a systematic review. *Diabet Med.* 2013
10. De Castro JM. Methodology, correlational analysis, and interpretation of diet diary records of the food and fluid intake of free-living humans. *Appetite.* 1994; 23:179–192. [PubMed: 7864611]
11. Brunner E, Stallone D, Juneja M, Bingham S, Marmot M. Dietary assessment in Whitehall II: comparison of 7 d diet diary and food-frequency questionnaire and validity against biomarkers. *Br J Nutr.* 2001; 86:405–414. [PubMed: 11570993]
12. Pachankis JE, Hatzenbuehler ML. The social development of contingent self-worth among sexual minority young men: an empirical test of the "Best Little Boy in the World" hypothesis. *Basic Appl Soc Psych.* 2013; 35:176–190.
13. Shrier LA, Shih MC, Beardslee WR. Affect and sexual behavior in adolescents: a review of the literature and comparison of momentary sampling with diary and retrospective self-report methods of measurement. *Pediatrics.* 2005; 115:e573–581. [PubMed: 15867022]
14. Mustanski B. The influence of state and trait affect on HIV risk behaviors: a daily diary study of MSM. *Health Psychol.* 2007; 26:618–626. [PubMed: 17845113]

15. Hankin BL, Fraley RC, Abela JR. Daily depression and cognitions about stress: evidence for a traitlike depressogenic cognitive style and the prediction of depressive symptoms in a prospective daily diary study. *J Pers Soc Psychol.* 2005; 88:673–685. [PubMed: 15796667]
16. Carney MA, Tennen H, Affleck G, Del Boca FK, Kranzler HR. Levels and patterns of alcohol consumption using timeline follow-back, daily diaries and real-time "electronic interviews". *J Stud Alcohol.* 1998; 59:447–454. [PubMed: 9647427]
17. Heeb JL, Gmel G. Measuring alcohol consumption: a comparison of graduated frequency, quantity frequency, and weekly recall diary methods in a general population survey. *Addict Behav.* 2005; 30:403–413. [PubMed: 15718058]
18. Pachankis JE, Westmaas JL, Dougherty LR. The influence of sexual orientation and masculinity on young men's tobacco smoking. *J Consult Clin Psychol.* 2011; 79:142–152. [PubMed: 21443320]
19. Newcomb ME, Mustanski B. Racial differences in same-race partnering and the effects of sexual partnership characteristics on HIV risk in MSM: a prospective sexual diary study. *J Acquir Immune Defic Syndr.* 2013; 62:329–333. [PubMed: 23187943]
20. Cooper ML. Toward a person x situation model of sexual risk-taking behaviors: illuminating the conditional effects of traits across sexual situations and relationship contexts. *J Pers Soc Psychol.* 2010; 98:319–341. [PubMed: 20085403]
21. Gillmore MR, Leigh BC, Hoppe MJ, Morrison DM. Comparison of daily and retrospective reports of vaginal sex in heterosexual men and women. *J Sex Res.* 2010; 47:279–284. [PubMed: 19544136]
22. Glick SN, Winer RL, Golden MR. Web-based sex diaries and young adult men who have sex with men: assessing feasibility, reactivity, and data agreement. *Arch Sex Behav.* 2012
23. Mustanski B, Starks TJ, Newcomb ME. Methods for the design and analysis of relationship and partner effects on sexual health. *Arch Sex Behav.* In press.
24. Leigh BC, Morrison DM, Hoppe MJ, Beadnell B, Gillmore MR. Retrospective assessment of the association between drinking and condom use. *J Stud Alcohol Drugs.* 2008; 69:773–776. [PubMed: 18781253]
25. Stone AA, Broderick JE, Schwartz JE, Shiffman S, Litcher-Kelly L, Calvanese P. Intensive momentary reporting of pain with an electronic diary: reactivity, compliance, and patient satisfaction. *Pain.* 2003; 104:343–351. [PubMed: 12855344]
26. Aaron LA, Turner JA, Mancl L, Brister H, Sawchuk CN. Electronic diary assessment of pain-related variables: is reactivity a problem? *J Pain.* 2005; 6:107–115. [PubMed: 15694877]
27. Hufford MR, Shields AL, Shiffman S, Paty J, Balabanis M. Reactivity to ecological momentary assessment: an example using undergraduate problem drinkers. *Psychol Addict Behav.* 2002; 16:205–211. [PubMed: 12236455]
28. Stone AA, Shiffman S. Ecological momentary assessment (EMA) in behavioral medicine. *Ann Behav Med.* 1994; 16:199–202.
29. Centers for Disease Control and Prevention. HIV Surveillance Supplemental Report. 2012. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data - United States and 6 U.S. dependent areas -2010.
30. Prejean J, Song R, Hernandez A, et al. Estimated HIV incidence in the United States, 2006-2009. *PLoS ONE.* 2011; 6:e17502. [PubMed: 21826193]
31. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. *AIDS Behav.* 2008; 12:118–126. [PubMed: 18034298]
32. Newcomb ME. Moderating effect of age on the association between alcohol use and sexual risk in MSM: evidence for elevated risk among younger MSM. *AIDS Behav.* 2013; 17:1746–1754. [PubMed: 23553348]
33. Mustanski BS. Are sexual partners met online associated with HIV/STI risk behaviours? Retrospective and daily diary data in conflict. *AIDS Care.* 2007; 19:822–827. [PubMed: 17573604]
34. Capaldi DM, Stoolmiller M, Clark S, Owen LD. Heterosexual risk behaviors in at-risk young men from early adolescence to young adulthood: prevalence, prediction, and association with STD contraction. *Dev Psychol.* 2002; 38:394–406. [PubMed: 12005382]

35. Fisher JD, Fisher WA. Changing AIDS-risk behavior. *Psychol Bull.* 1992; 111:455–474. [PubMed: 1594721]
36. Bandura, A. *Social foundations of thought and action: a social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall; 1986.
37. Fishbein, M.; Ajzen, I. *Belief, attitude, intention, and behavior: an introduction to theory and research.* Reading, MA: Addison-Wesley; 1975.
38. Kalichman SC, Picciano JF, Roffman RA. Motivation to reduce HIV risk behaviors in the context of the Information, Motivation and Behavioral Skills (IMB) model of HIV prevention. *J Health Psychol.* 2008; 13:680–689. [PubMed: 18519441]
39. Mustanski BS, Newcomb ME, Du Bois SN, Garcia SC, Grov C. HIV in young men who have sex with men: a review of epidemiology, risk and protective factors, and interventions. *J Sex Res.* 2011; 48:218–253. [PubMed: 21409715]
40. Mustanski B. Ethical and regulatory issues with conducting sexuality research with LGBT adolescents: a call to action for a scientifically informed approach. *Arch Sex Behav.* 2011; 40:673–686. [PubMed: 21528402]
41. The University of California at San Diego Task Force on Decisional Capacity. *Procedures for determination of decisional capacity in persons participating in research protocols.* San Diego: The University of California; 2003.
42. Dunn LB, Jeste DV. Enhancing informed consent for research and treatment. *Neuropsychopharmacol.* 2001; 24:595–607.
43. Mustanski BS. Getting wired: exploiting the Internet for the collection of valid sexuality data. *J Sex Res.* 2001; 38:292–301.
44. Carey MP, Schroder KE. Development and psychometric evaluation of the brief HIV Knowledge Questionnaire. *AIDS Educ Prev.* 2002; 14:172–182. [PubMed: 12000234]
45. Jaworski BC, Carey MP. Development and psychometric evaluation of a self-administered questionnaire to measure knowledge of sexually transmitted diseases. *AIDS Behav.* 2007; 11:557–574. [PubMed: 17016760]
46. Mimiaga MJ, Reisner SL, Cranston K, et al. Sexual mixing patterns and partner characteristics of black MSM in Massachusetts at increased risk for HIV infection and transmission. *J Urban Health.* 2009; 86:602–623. [PubMed: 19466554]
47. Raudenbush, SW.; Bryk, AS.; Cheong, YF.; Congdon, RT.; du Toit, M. *HLM 7: Hierarchical linear and nonlinear modeling.* Chicago, IL: Scientific Software International; 2011.
48. Newcomb ME, Mustanski B. Cognitive influences on sexual risk and risk appraisals in men who have sex with men. *Health Psychol.* 2013 Epub 8/26/2013.
49. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Dec.* 1991; 50:248–287.
50. Gosling SD, Vazire S, Srivastava S, John OP. Should we trust web-based studies? A comparative analysis of six preconceptions about internet questionnaires. *Am Psychol.* 2004; 59:93–104. [PubMed: 14992636]



**Figure 1. Moderating Effects of Social Cognitive Variables on Change in Outcome Variables Over Time, N = 137**  
 NOTE: (A) The effect of week of data collection X condom use intentions on UAI. (B) The effect of week of data collection X risk reduction motivation on UAI. (C) The effect of week of data collection X social norms of condom use on risk appraisals. (D) The effect of week of data collection X UAI X risk reduction motivation on risk appraisals. These figures group MSM into low and high levels of social cognitive variables by averaging the lower and upper quartiles of each variable. This is done solely for illustrative purposes. UAI = unprotected anal intercourse.

**Table 1**  
**Participant Demographics: Men Who Have Sex with Men Recruited Online, 2011**

Variable	% of Full Sample <i>N</i> (%)	% of Analytic Sample <i>N</i> (%)
Age		
16-20	28 (19.6)	27 (19.7)
21-25	31 (21.7)	30 (21.9)
25-30	36 (25.2)	33 (24.1)
31-40	48 (33.5)	47 (34.3)
Mean ( <i>SD</i> )	27.53 (7.33)	27.54 (7.40)
Race/Ethnicity		
White/Caucasian	53 (37.1)	50 (36.5)
Black/African American	32 (22.4)	31 (22.6)
Hispanic/Latino	39 (27.3)	37 (27.0)
Asian/Pacific Islander	6 (4.2)	6 (4.4)
Other or Multi-Racial	13 (9.1)	13 (9.5)
Sexual Orientation		
Gay	111 (77.6)	106 (77.4)
Bisexual	29 (20.3)	28 (20.4)
Heterosexual (same-sex attracted)	3 (2.1)	3 (2.2)
Geographic Region		
Northeast	37 (25.9)	36 (26.3)
Midwest	40 (28.0)	37 (27.0)
West Coast	42 (29.4)	40 (29.2)
South/Southeast	24 (16.8)	24 (17.5)
Total <i>N</i>	143	137

NOTE: There were no significant differences between the full and analytic sample for any of the above described demographic characteristics.

**Table 2**  
**Summary of Moderating Effects of Social Cognitive Variables on the Association between**  
**Week of Data Collection and Sexual Risk Behavior, N = 137**

Cross-Level Interactions	UAI, Adjusted Odds Ratio (95% CI)	Serodiscordant UAI, Adjusted Odds Ratio (95% CI)
Week of Data Collection	--	--
X HIV Knowledge	0.98 (0.96 – 1.01)	0.99 (0.97 – 1.01)
X Risk Reduction Motivation	0.93 (0.93 – 1.01) †	0.94 (0.89 – 0.99) *
X Perceived Severity of Infection	0.96 (0.83 – 1.10)	1.08 (0.86 – 1.35)
X Intentions to Use Condoms	1.11 (1.00 – 1.22) *	1.05 (0.96 – 1.16)
X Social Norms of Condom Use	0.94 (0.82 – 1.08)	0.93 (0.74 – 1.17)
X Condom Use Self-Efficacy	1.00 (0.93 – 1.08)	0.96 (0.89 – 1.05)

NOTE: Each model was adjusted for the main effects of social cognitive variables at Level 2. All effects preceded by an “X” refer to the cross-level interactions between these variables and week of data collection in describing sexual risk behavior. UAI = unprotected anal intercourse. CI = Confidence Interval.

\*  $p < .05$ ,

†  $p < .1$ .



**Table 3**  
**Summary of Moderating Effects of Social Cognitive Variables on the Association between**  
**Week of Data Collection and Risk Appraisals, N = 137**

Cross-Level Interactions	Model 1		Model 2	
	Adjusted Standardized Coefficients	<i>p</i> -value	Adjusted Standardized Coefficients	<i>p</i> -value
Week of Data Collection	--	--	--	--
X HIV Knowledge	<0.001	0.983	- 0.003	0.513
X Risk Reduction Motivation	- 0.015	0.158	0.009	0.582
X Perceived Severity of Infection	0.020	0.148	0.015	0.322
X Intentions to Use Condoms	- 0.022	0.131	- 0.023	0.152
X Social Norms of Condom Use	0.044	0.032	0.024	0.349
X Condom Use Self-Efficacy	0.004	0.693	0.006	0.577
UAI x Week of Data Collection	--	--	0.010	0.730
X HIV Knowledge	--	--	0.008	0.218
X Risk Reduction Motivation	--	--	- 0.055	0.014
X Perceived Severity of Infection	--	--	- 0.016	0.638
X Intentions to Use Condoms	--	--	0.001	0.971
X Social Norms of Condom Use	--	--	0.072	0.132
X Condom Use Self-Efficacy	--	--	- 0.011	0.648

NOTE: Model 1 examines the interactions between social cognitive variables and week of data collection in describing risk appraisals. Model 2 examines the three-way interactions between social cognitive variables, UAI, and week of data collection in describing risk appraisals. Each model was adjusted for the main effects of UAI at Level 1 and social cognitive variables at Level 2. All effects preceded by an "X" refer to the cross-level interactions between these variables and week of data collection in describing sexual risk behavior. UAI = unprotected anal intercourse.