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Prospective State and Trait Predictors of Daily Medication Adherence Behavior in HIV

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Abstract

Background—Many persons living with HIV (PLWH) are nonadherent to medication. Trait-level measures that ask about predictors of adherence in the abstract may not adequately capture state-level daily variability that more directly impacts adherence.

Objectives—This preliminary study was designed to test six predictors of electronically monitored adherence at both the state and trait levels, and to compare their relative effects.

Methods—Using a smartphone, 87 PLWH completed randomly cued daily surveys on thoughts, mood, stress, coping, social support, and treatment motivation. All participants also completed baseline surveys on each construct. These state and trait variables were tested as prospective predictors of next-day adherence in multilevel models, and their relative importance was quantified. The analysis sample consisted of 53 PLWH who stored their most frequent antiretroviral medication in a bottle that time-stamped openings to measure adherence.

Results—Higher state-level motivation, $OR = 1.55$, 95% CI [1.07, 2.24], and negative mood, $OR = 1.33$, 95% CI [1.07, 1.63], predicted greater adherence the following day. Importantly, these effects were only found at the state level. Trait-level control beliefs predicted greater adherence,

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$OR = 1.65$, 95% CI [1.17, 2.35], but contrary to prediction, validated trait-level measures of mood, stress, coping, social support, and motivation did not.

Discussion—Trait- and state-level measures predicted adherence, but there were differences between them. Motivation for treatment and negative mood predicted adherence when measured the preceding day, but not as aggregate measures. At the trait level, only control beliefs predicted adherence. Researchers should consider state-level variations in mood and motivation as possible explanations for nonadherence. Interventions could be developed to target state-level variables.

Keywords

adherence; antiretroviral therapy; ecological momentary assessment; HIV; longitudinal research

Persons living with HIV (PLWH) must take antiretroviral therapy (ART) medications very consistently to lower their viral load, control symptoms, prevent treatment resistance, and reduce the odds of transmitting HIV to others (Paterson et al., 2000; Bangsberg et al., 2006). Evidence-based interventions can improve adherence, but their effect sizes are small (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). Nonadherence is a problem even for PLWH who take newer ART regimens with fewer doses per day (Langness, Cook, Gill, Boggs, & Netsanet, 2014). ART adherence, therefore, remains low despite advances in efficacy, reductions in adverse events, and more convenient drug delivery options (Haynes, 2010; Cook, 2006).

Discrepancies between State-Level and Trait-Level Measures

To understand why nonadherence problems persist, it is crucial to recognize that medication adherence is not a choice made at a single point in time. Instead, patients experience medication-taking behavior as part of an ongoing series of psychological events or momentary states in the context of their day-to-day lives (Shiffman, Stone, & Hufford, 2008; Reis, 2012). Even behaviors that are usually habitual, like taking medication, can change based on day-to-day variability in mood, motivation, or other factors that serve as barriers or facilitators. In this article, the term “state-level” is used to describe intensive longitudinal data collected by frequent measurement of experiences close to the times they occur; a method known as ecological momentary assessment.

In contrast to states, which are temporary and changeable psychological experiences (Courvoisier, Eid, & Nussbeck, 2007; Fridhandler, 1986), a trait is a long-term and stable pattern of interpreting and responding to events that has possible genetic underpinnings (Terracciano et al., 2010). States and traits are often labeled with the same construct names, which contributes to confusion between them. However, the difference is illustrated by the statements, “I am anxious” (state), versus, “I am an anxious person” (trait). A major limitation of current knowledge about adherence is that most studies are retrospective, identifying nonadherence after the fact from pharmacy records or self-report (Reynolds, 2004). Even studies that use monitoring technologies, such as Medication Event Monitoring System (MEMS), pill bottles usually assess nonadherence risk factors retrospectively (Cook, Schmiege, McClean, Aagaard, & Kahook, 2012) with surveys that ask about a person’s

average or typical experiences over a period of time, such as a week or a month. We refer to such aggregated summaries of experiences as “trait-level” measures.

State- and trait-level measures of a construct are related, but only moderately correlated (Ptacek, Pierce, & Thompson, 2006), and they show different predictive relationships to behavior (Mustanski, 2007; Barta et al., 2008; Janda, Markowski, Derlega, Nezlek, & McCain, 2006). This difference likely occurs because as experience transitions into memory, people remember or re-interpret state-level events based on their conscious thoughts or beliefs (Schwartz, 2012). There are reasons to believe that state- and trait-level measures also assess different systems at the neuropsychological level, where state-level experiences and behaviors are generated by a set of automatic perceptual and behavioral processes, but trait-level measures capture our reflections about those experiences in memory and language (Stanovich, 2008). These systems can produce quite different responses to similar stimuli, with the automatic system, for instance, being more influenced by surface features of messages and social perceptions (Mlodinow, 2012).

Although momentary states have not been studied as predictors of ART adherence, they have been found to predict adherence to HIV prevention recommendations in four studies. In two of these, alcohol use was found to be an in-the-moment risk factor for unprotected sex (Barta, Tennen, & Kiene, 2010; Kiene et al., 2008). In a third, prevention behaviors were predicted by control beliefs, mood, and motivation based on daily electronic surveys (Cook, McElwain, & Bradley-Springer, 2016). Finally, a fourth study specifically compared state and trait variables, finding that state-level anxiety and sexual arousal predicted HIV risk behavior, while state-level positive mood reduced it. However, none of these predicted HIV risk behavior when they were measured using trait-level retrospective questionnaires (Mustanski, 2007).

Theoretical Framework

Because state-level variables may have different relationships to behaviors than trait-level constructs with similar names, existing theoretical frameworks are unlikely to translate well to the state level of measurement (Riley et al., 2011). State-level data have become increasingly common because of mobile technology, but studies of such data have been largely a theoretical. The current study was based on a model suggesting six state-level situational and experiential variables that might affect adherence behavior, incorporating constructs from multiple theories of health behavior (Cook, McElwain, & Bradley-Springer, 2010). The suggested predictor variables in this model are control beliefs (a measure of feelings of control in one’s everyday life), momentary mood (a positive-to-negative continuum of affective states), stress (in-the-moment experiences of acute or chronic stressors), coping (use of active and/or avoidant strategies to manage stressors), perceived social support (feeling loved, accepted, and cared for by others), and motivation for ART. These predictors have been studied as traits in other adherence research (e.g., Cook et al., 2015), but they vary in the course of daily life and may be best understood as momentary states. Figure 1 shows an adaptation of the previously published model as applied to ART adherence behavior: We expected negative mood and stress to decrease adherence, and higher control beliefs, coping, social support, and motivation for treatment to increase it.

Purpose

This preliminary study was designed to test the relationship of electronically monitored adherence to six theory-based predictors at both the state and trait levels, and to compare state and trait measures' relative effects. Mobile internet technologies facilitate state-level data collection, and adherence also can be monitored in real time with devices like Medication Event Monitoring System (MEMS) pill bottles, permitting a match between momentary state data and behavioral measures of adherence. Rather than focusing on the usual question, "Which patients are nonadherent?," a study of momentary states can address the potentially more clinically useful question, "Under what circumstances are patients nonadherent?" (Dunbar-Jacob & Mortimer-Stephens, 2001). Consistent with the model presented above, we expected each state-level predictor to have a significant effect on daily adherence behavior over all study weeks. Further, we expected the state-level measures to have stronger relationships to day-by-day adherence behavior than well-established, trait-level measures collected at the beginning of the study.

Methods

Participants

Participants were HIV-infected women ($n = 19$) and men ($n = 68$) recruited from an outpatient infectious diseases clinic in Denver, Colorado. The Colorado Multiple Institutional Review Board approved this study, and all participants provided written informed consent. PLWH were recruited at the time of a regularly scheduled clinic visit with their usual HIV care providers, who briefly introduced the study and then referred interested patients to a research team member to complete the informed consent process. Study inclusion criteria were: (a) documented HIV infection and current ART based on medical records; (b) ability to speak, read, and write English; (c) older than 18 years of age and younger than 81 years of age; and (d) ability to use a smartphone after initial training. Participants were excluded only if they had a level of substance abuse, cognitive impairment, psychiatric disorder, medical comorbidity, or another condition so severe that the referring clinician did not want them included in the study. Quota sampling was used to ensure sample diversity, with providers asked to recruit patients in specific demographic categories, such as women and minority group members.

Procedures

During an intake session, usually completed immediately after enrollment but in a few cases scheduled at a later time, each participant completed baseline questionnaires to measure potential predictors of ART adherence at the trait level. Next, a research assistant provided the participant with a smartphone (Samsung hardware and Android operating system) that was preloaded with Apptive scheduling software. This software delivered a cue for the participant to take the state-level survey at a randomly determined time each day. Survey timing was not linked to ART dosing because of concern that the alert would also remind participants to take medication and, thereby, interfere with accurate measurement of the dependent variable. This led to some survey observations occurring before medication dosing for that day and others occurring after; however, this variability did not affect the

primary analysis, which focused on state-level variables as prospective predictors of adherence the following day. Participants completed the survey by clicking a secure URL to a page hosted by SurveyMonkey. During the intake session, participants were instructed on smartphone use and practiced completing the survey.

During the intake session, PLWH received a Medication Event Monitoring System (MEMS) bottle that electronically timestamped bottle openings as a behavioral measure of adherence. They were instructed to store their most frequent ART medication in the bottle, and to open it only when taking medication. They received a tip sheet on use of the MEMS bottle to increase accuracy. Participants were aware of the purpose of the MEMS bottle, but our analysis tested for reactive measurement as described below. PLWH used the bottle for 10 weeks, which was long enough to eliminate reactivity in past research (Cook et al., 2012). Participants were given a telephone number to call investigators with any questions or technical difficulties. A number of participants did use this number, most often with questions about other smartphone functions. State-level data were de-identified, and confidentiality was discussed during informed consent.

Participants were asked to return to the clinic 10 weeks after intake for a follow-up visit—when they returned the MEMS bottle and completed the study. Some participants delayed the follow-up until their next regular clinic appointment—usually three months after the intake visit. PLWH were paid incentives of \$25 for each of the two in-person visits. They also could keep their smartphone at the end of the study—although they then had to pay for their own phone service.

Measures

Primary outcome: Adherence based on MEMS—MEMS bottles track openings rather than actual pill use, but are considered a high-quality proxy measure of adherence (Chesney, 2006). Reliability of the measure is supported by a low rate of technical errors (Cook et al., 2012), and validity is supported by correlations between MEMS and adherence-linked physiological outcomes such as viral load (Liu et al., 2001). A run-in period was included to reduce the level of reactivity (Cook et al., 2012), and all analyses included a statistical control for reactivity.

Demographic and clinical variables—Participants provided demographic information on their age; gender; sexual orientation; level of education; employment; race/ethnicity; housing or homelessness; and insurance or other access to care. Other data were extracted from medical records with authorization, including latest HIV viral load; latest CD4+ T cell lab result; ART medication regimen; comorbid medical conditions; mental health conditions; and substance use.

Predictors of adherence—Participants completed daily surveys on their smartphones as described above, using items designed specifically for daily survey administration and tested in prior research (Cook et al., 2010). Participants also completed typical retrospective trait-level questionnaires at the time of study enrollment. Both types of measures were tested as prospective predictors of adherence. Table 1 provides detailed information on state and trait measures. Each trait-level construct was also evaluated with a reworded version of the exact

items used in the state-level survey (e.g., with “in general” or “over the past month” substituted for “right now”). These items did not have prior reliability or validity evidence, but were included as a check on method variance between the trait-level and state-level survey items (Kazdin, 2003).

Data Analysis

For all survey instruments, whether at the state or trait level, subscale scores were created by averaging across items based on the original reported factor structure. For the MEMS measure of adherence, participants taking once-daily medication ($n = 38$, 44.8%) were given a score of 1 if they took their medication and 0 if not. Those taking twice-per-day medication ($n = 49$, 55.2%) were given a daily adherence score of 1 if both doses were taken, 0.5 if one of the two doses was taken, and 0 if neither dose was taken. This strategy allowed us to weight the participants with twice-per-day medication the same as those taking once-daily medication, but to still account for partial adherence. No participants in this study were prescribed three-times-per-day ART.

Tests of state and trait predictors—Nonlinear mixed models (NLMM) were estimated to test the effects of predictor variables on adherence using the PROC GLIMMIX command in SAS version 9.4, with participant as a random factor, group-mean centering for Level 1 variables, and grand-mean centering for Level 2 variables. Daily MEMS-based adherence was the Level 1 criterion variable in all analyses. Separate equations were estimated for each construct and a comparisonwise alpha of .05 was used for each test, because this preliminary study was designed to identify potentially important state variables rather than to select among them. A two-step analysis process was used for each construct, focusing first on the trait-level measure as a Level 2 predictor of adherence, and then adding the state-level measure of the same construct as a Level 1 predictor in a second step. We included study week as a Level 1 covariate in all analyses to control for reactive measurement, which would produce higher adherence levels at some study weeks than others. Each analysis of a state-level predictor also included the trait-level measure of the same construct as a Level 2 covariate, because states were considered important only if they added information to typical trait-level measures. To test for potential effects of serial autocorrelation in the state-level data, we also examined models with an AR(1) structure in a sensitivity analysis, but conclusions were unaffected so the unstructured models are presented.

Missing data—Because days without MEMS data were coded as “nonadherent,” there was no missing data on the dependent variable, and all days with complete surveys were analyzed. NLMM uses all available data by estimating effects via maximum likelihood estimation, so no further adjustment was needed for the fact that we had varying amounts of daily survey data per participant. Missing data on trait-level measures ranged from 1.9% to 7.5%, and were handled via multiple imputation in SAS. We tested the impact of this strategy in a sensitivity analysis by omitting cases with missing data; conclusions were unchanged, so complete data are presented.

Power—Power for multilevel models depends on the number of observations as well as the number of participants, after correction for the intraclass correlation (ICC) of data from the

same person—which was conservatively estimated at .70 (Hox, 2002). With as few as 33 data points (consistent with data completeness in a previous study: Cook et al., 2010) from as few as 62 participants, power to detect within-person effects was estimated at .80 for moderate effect sizes ($r = .39$, based on the weakest significant time-lagged effect in the prior study) at $\alpha = .05$ for predictors that were expected to have independent effects on adherence. The obtained sample of 87 PLWH allowed for attrition, and 34 participants did not return their MEMS bottle for data download. Because this was the dependent variable, the final sample size was 53 for all analyses.

Comparison of state and trait predictors—As a final step, to compare the relative effects of state-versus trait-level predictors on daily ART adherence behavior, we examined odds ratios for the state and trait predictors in the multilevel models. This allowed us to determine how much each type of measure added to our ability to predict daily ART adherence behavior, with larger odds ratios indicating stronger effects when variables were tested using a similar approach. As an exploratory analysis, we also examined the direct relationship of trait to state measures.

Results

Participant Characteristics

Of 158 PLWH approached for the study, 87 chose to participate. Of the others, 17 did not meet inclusion criteria (e.g., did not manage their own medication, did not speak English, or were not receiving ART); two were too medically ill and five too mentally ill to participate; and 47 were eligible but refused, usually saying they were too busy or didn't want to discuss adherence. The final analysis sample was therefore 53 of the 87 participants who had behavioral adherence data. Table 2 shows demographics for the full sample and for the 53 who returned MEMS bottles, with no significant differences that would suggest sampling bias in the obtained results.

The sample was relatively diverse despite the fact that Colorado's PLWH are most often White men who have sex with men (MSM). Although the sample included a higher percentage of White MSM than the national demographics of the U.S. HIV epidemic (The White House, 2015), the study nevertheless included relatively high percentages of women and minority participants—groups of PLWH who tend to be underrepresented in research. Other variables showing good diversity were employment (31% working part or full time, 56% unemployed, 8% disabled, 3% students); primary language (92% English, 6% English and Spanish, 1% English and Igbo); and literacy (94% literate, 6% needed assistance reading although they were able to complete daily surveys with instruction). Finally, participants had a range of insurance—13% private; 41% Medicare/Medicaid; 38% Ryan White or other public insurance; and 8% self-pay or uninsured—and 30% received ART through the AIDS Drug Assistance Program.

Participants' HIV was generally well-controlled, with 91.1% having an undetectable viral load (i.e., < 200 copies/mL)—a typical finding at Ryan White clinics (Doshi et al., 2015). Nevertheless, their average adherence was only 72.9% ($Mdn = 78.6\%$, $SD = 24.6\%$, range: 1% to 100%) over 10 weeks of monitoring. Participants had $M = 6.73$ ($SD = 4.98$) other

conditions in addition to HIV, including 25.0% with serious and persistent mental illness (e.g., bipolar disorder, major depression with suicidal ideation, schizoaffective disorder) and 53.6% with substance abuse. Other comorbidities included other sexually transmitted diseases (39.3%), respiratory disorders (32.1%), gastrointestinal disorders (32.1%), endocrine disorders (32.1%), and pain (28.6%).

Differences by Medication Regimens

Because the sample was about evenly split between PLWH with once-daily and twice-daily ART regimens, tests were run to compare these groups' demographic characteristics. A greater percentage of PLWH taking twice-daily ART were men (40/48, 83%) than those with once-daily regimens (24/39, 62%), $\chi^2 = 5.67$, $p = .02$, $\phi = .26$. There were no differences in minority status, $p = .80$, or average age, $p = .17$. Most importantly, MEMS-based adherence was similar across once-daily ($M = 76.4\%$) and twice-daily regimens ($M = 67.8\%$), $t(56) = 1.33$, $p = .19$, $d = 0.36$. Based on few differences by regimen, all further analyses used the aggregated sample.

Data Completeness and MEMS Reactivity

By the end of the study, PLWH completed 3,998 surveys, or $M = 46.0$ per person. On average, this represented 65% of possible days during the planned 10 weeks of data collection (10 weeks $\times$ 7 days = 70 days), similar to data completeness in a prior study (Cook et al., 2010). Average study duration was 78.5 days with wide variability ($SD = 74.6$): One participant discontinued as early as two days and another completed surveys for 150 days due to scheduling considerations. This was also consistent with prior experience. A test for reactivity showed higher adherence in the first three weeks of the study, starting at 81% in week 1, but dropping to 73% by week 4 and staying consistent thereafter. This suggests that reactivity resolved relatively quickly in this study. Nevertheless, we controlled for reactive measurement by including study week as a covariate in all subsequent analyses. As expected, there was a main effect of study week on adherence—a finding that reflects reactivity. But importantly, a sensitivity analysis showed no difference in the other findings whether or not study week was included in the models.

Trait-Level Predictors of Adherence

Relationships between trait-level baseline measures and daily MEMS-based adherence, controlling for study duration, are shown in the left-hand columns of Table 3. Using validated instruments from the literature to assess each construct, only the trait-level measure of control beliefs predicted daily ART adherence. Contrary to prediction, trait-level mood, stress, coping, social support, and motivation did not predict adherence. The effects of additional trait-level measures that used wording borrowed from the state-level scales were tested to determine the potential effects of instrumentation on the results. Correlations between the validated and ad hoc trait-level measures were moderate to high for mood, stress, and social support ($r = .69$ to $.74$), but lower for control beliefs, coping, and motivation ($r = .12$ to $.32$). Using the ad hoc measures, there was again a significant effect for control beliefs, and also significant positive effects for coping and social support (p -values $< .05$). Because no effects were found for these variables using either the validated

trait-level measures or the state-level scales, described in the following section, we did not interpret effects for the ad hoc coping and social support scales.

State-Level Predictors of Adherence

In multilevel analyses of state-level predictors that controlled for study duration and the corresponding trait-level measures, shown in the right-hand columns of Table 3, greater motivation for ART predicted adherence the following day as anticipated based on the theoretical model in Figure 1. Additionally, poorer state-level mood predicted better adherence the following day. These results were checked in a sensitivity analysis using models predicting same-day adherence, which revealed that motivation had a concurrent, as well as a prospective, effect. However, the effect of mood on adherence was only seen in the prospective analysis, and no other state-level variables had significant relationships to same-day adherence.

Comparison of State and Trait Predictors

Finally, we interpreted odds ratios for the state- and trait-level predictors of adherence (also shown in Table 3) to gauge the relative size of the effect for each. There was no consistent pattern in which either the state or trait effects was greater than the other; rather, the pattern varied by construct. As reflected in the significance tests presented above, the odds ratio for trait-level control beliefs was 1.65, while the odds ratio for state-level control beliefs was close to 1 (indicating no effect). Similarly, the effect of state-level mood was 1.33 and the effect of state-level motivation was 1.55, while the corresponding trait-level measures of these constructs had odds ratios close to 1. Although other predictors had nonsignificant effects, it is noteworthy that the effect size for stress was positive at both the state ($OR = 1.59$) and trait ($OR = 1.30$) levels, while the effect size for coping was negative at both the state ($OR = 0.91$) and trait ($OR = 0.54$) levels. The negative effect size for coping might be due to a measure that asked participants about the number of coping strategies used rather than their effectiveness, because using more strategies might actually reflect ineffective coping. Social support had negative effects at the state level ($OR = .90$), and positive effects at the trait level ($OR = 1.25$), but these weak and nonsignificant effect sizes centered on 1 likely reflect no true effect.

In exploratory analyses, we also used multilevel models to test the direct effect of each trait-level measure on the corresponding state-level measure as a Level 1 outcome variable. Mood ($p = .002$), stress ($p < .001$), and social support ($p < .001$) each predicted their respective state-level measure, whereas control beliefs, coping, and motivation did not. The pattern of state-trait relationships was not consistently related to whether each variable predicted adherence, and these results support the general conclusion that state and trait measures tend to be independent.

Discussion

When predictor variables were measured using methods similar to those of most published studies (i.e., as trait-level responses to retrospective questionnaires about average experiences over a period of time), only perceived control predicted daily ART adherence.

Five other constructs—mood, stress, coping, social support, and motivation—did not prospectively predict adherence at the trait level. These findings were surprising because all trait-level measures were validated scales, originally selected based on their relationships to adherence in prior research. However, this preliminary study of state versus trait effects differed from most ART adherence studies in at least two important ways: First, the measure of adherence was behavioral, while a majority of older studies have used self-report instruments, such as the AIDS Clinical Trials Group Adherence Scale (Chesney et al., 2000)—a strategy that may inflate the apparent relationship of predictors to adherence based on shared method variance (Kazdin, 1992). Second, our analysis was prospective and used multilevel models to predict daily MEMS-based adherence, while most studies use cross-sectional or retrospective designs that may overestimate the strength of predictive relationships with adherence data that are also measured in aggregate. Finally, most participants had well-controlled HIV even though their average adherence was suboptimal at 72.9%. It is possible that other predictors might be important in identifying patients with less well-controlled HIV who rarely take medication or are not retained in care.

When the same constructs were considered at the momentary state level of measurement, motivation and mood emerged as significant predictors of next-day ART adherence. Notably, the effects of both mood and motivation emerged only at the state level, not based on retrospective aggregate questionnaires. This is consistent with the idea that participants may not accurately remember or report their experiences on trait-level measures (Schwartz, 2012).

A significant effect of state-level motivation fits the theoretical model presented above, which shows motivation as the closest predictor of state-level behavior (Cook et al., 2010). Constructs related to motivation have a proximal role to behavior in other well-known theories at the trait level, such as intention in the theory of planned behavior (Ajzen & Fishbein, 2004), self-efficacy in the social cognitive model (Bandura, 1997), and readiness for change in self-determination theory (Ryan & Deci, 2000). Although different models have different names for these constructs, they overlap significantly as in Herzog and Blagg's (2007) demonstration that scores on a motivation scale outperform the widely used stages-of-change readiness measure (DiClemente et al., 1991) in predicting behavior. As noted above, trait-level motivation failed to predict adherence in this study.

Contrary to prediction, the direction of mood's effect was that people with poorer moods (i.e., less happy) were more adherent to ART. It was expected that feeling more depressed might lead to low energy or hopelessness would interfere with adherence, but the obtained result was more in line with findings about "depressive realism," which suggests people may actually process information more accurately when their moods are not elevated (Alloy & Abramson, 1979). It should be noted that the mood questions were not a measure of clinical depression and that "low mood" likely represented mild dysthymia or an absence of strong happiness. More clinically significant depression still might interfere with cognitive processing and disrupt adherence.

Directions for Future Research

Because of documented differences between state- and trait-level predictors, existing theories of health behavior provide an inadequate basis for understanding state-level data (Riley et al., 2011). The current preliminary study provides further evidence about state-level constructs that are postulated to affect health behaviors, such as adherence in the first integrated model that was designed specifically to explain state-level influences on behavior. Although this preliminary study found main effects of some state-level variables on adherence, additional study is needed both to validate the current results and to extend our conceptual understanding of states and traits. The current analysis did not test a proposed mediation pathway among momentary states, and trait-level variables also might affect momentary states earlier in the proposed causal sequence or moderate the relationships among state-level variables.

In addition to theory development, a focus on state-level variables could lead to improved adherence-promoting interventions, which generally have modest effects as shown in a Cochrane Review of 182 randomized controlled adherence trials by Haynes et al. (2008). The same mobile technology that enabled monitoring of state-level variables in this study can also be used to deliver intervention messages—which could be offered at times or on topics that have been found to matter at the state level. As an example, the current study revealed that daily elevations in mood were a risk factor for next-day nonadherence. Messages accordingly could be targeted to PLWH on days when they report more positive moods, reminding them that maintaining ART adherence is important even when they feel well.

Limitations

Strengths of this study were included a behavioral measure of adherence, a prospective design, and randomly cued prompts for longitudinal data collection. There were also some weaknesses. Because of concerns about cueing adherence behavior via the daily survey, state-level data were measured at random times not tied to ART use, and state-level variables were tested as predictors of adherence the following day. It is possible that measuring state-level predictors immediately before ART dosing times on the same day would have resulted in stronger effects. Second, there was a reactive measurement effect of using MEMS bottles, which might have affected the results. But we did test for the possibility that MEMS monitoring affected adherence, and controlled for study week in all analyses. Third, although data appeared to be missing at random, sample size was slightly lower than planned because some participants did not return MEMS bottles. The analysis sample and overall sample were demographically similar, which reduces concern about sampling bias. Still, very small, state-level effects might have been missed due to power limitations, and this study remains a preliminary investigation of a new model describing state-level effects that is in need of replication. Fourth, different measures were used to assess the state- and trait-level constructs. This decision was made in order to use well-validated tools at each level of measurement, but different item wording might explain state-trait discrepancies in the results. We did test for this possibility in a separate analysis using trait items identical to the state items, and there were still substantial differences between the effects of trait and state measures. Finally, although there was no evidence of sampling bias, the sample

included more White MSM than the U.S. population of PLWH. This limitation reflects general demographics of the Western U.S., and suggests a need for replication with more diverse samples of PLWH.

Conclusions

Overall, the effects of state-level and trait-level predictors were comparable in magnitude ($ORs = 1.33$ to 1.65 for significant state and trait predictors of adherence), but it is noteworthy that different variables predicted adherence at the state and trait levels. In particular, the finding that state-level negative mood predicted next-day adherence is a novel result that might suggest opportunities for state-level interventions. Furthermore, the prospective effect of state-level motivation supports the central role of this variable as a predictor of adherence in the proposed theoretical model, and as a potential target for intervention. Further studies of state-level predictors may yield important data about when PLWH do or do not take ART medications, and are likely to provide information that is not available through standard trait-level measures.

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References

- Ajzen I, Fishbein M. Questions raised by a reasoned action approach: Comment on Ogden (2003). *Health Psychology*. 2004; 23:431–434. DOI: 10.1037/0278-6133.23.4.431 [PubMed: 15264981]
- Alloy LB, Abramson LY. Judgment of contingency in depressed and nondepressed students: Sadder but wiser? *Journal of Experimental Psychology: General*. 1979; 108:441–485. DOI: 10.1037/0096-3445.108.4.441 [PubMed: 528910]
- Bandura, A. *Self-efficacy: The exercise of control*. New York, NY: Freeman; 1997.
- Bangsberg DR, Acosta EP, Gupta R, Guzman D, Riley ED, Harrigan PR, ... Deeks SG. Adherence-resistance relationships for protease and non-nucleoside reverse transcriptase inhibitors explained by virological fitness. *AIDS*. 2006; 20:223–231. DOI: 10.1097/01.aids.0000199825.34241.49 [PubMed: 16511415]
- Barta WD, Portnoy DB, Kiene SM, Tennen HA, Abu-Hasaballah KS, Ferrer R. A daily process investigation of alcohol-involved sexual risk behavior among economically disadvantaged problem drinkers living with HIV/AIDS. *AIDS and Behavior*. 2008; 12:729–740. DOI: 10.1007/s10461-007-9342-4 [PubMed: 18071894]
- Barta WD, Tennen H, Kiene SM. Alcohol-involved sexual risk behavior among heavy drinkers living with HIV/AIDS: Negative affect, self-efficacy, and sexual craving. *Psychology of Addictive Behaviors*. 2010; 24:563–570. DOI: 10.1037/a0021414 [PubMed: 21198219]
- Carver CS. You want to measure coping but your protocol's too long: Consider the Brief COPE. *International Journal of Behavioral Medicine*. 1997; 4:92–100. DOI: 10.1207/s15327558ijbm0401_6 [PubMed: 16250744]
- Chesney MA. The elusive gold standard: Future perspectives for HIV adherence assessment and intervention. *Journal of Acquired Immune Deficiency Syndromes*. 2006; 43:S149–S155. DOI: 10.1097/01.qai.0000243112.91293.26 [PubMed: 17133199]
- Chesney MA, Ickovics JR, Chambers DB, Gifford AL, Neidig J, Zwickl B, Wu AW. Self-reported adherence to antiretroviral medications among participants in HIV clinical trials: The AACTG

adherence instruments. *AIDS Care*. 2000; 12:255–266. DOI: 10.1080/09540120050042891 [PubMed: 10928201]

- Cook, PF. Adherence to medications. In: O'Donohue, WT., Levensky, ER., editors. *Promoting treatment adherence: A practical handbook for health care providers*. Thousand Oaks, CA: Sage; 2006. p. 183–202.
- Cook PF, McElwain CJ, Bradley-Springer L. Feasibility of a daily electronic survey to study prevention behavior with HIV-infected individuals. *Research in Nursing & Health*. 2010; 33:221–234. DOI: 10.1002/nur.20381 [PubMed: 20499392]
- Cook PF, McElwain CJ, Bradley-Springer LA. Brief report on ecological momentary assessment: Everyday states predict HIV prevention behaviors. *BMC Research Notes*. 2016; 9:9.doi: 10.1186/s13104-015-1814-4 [PubMed: 26728848]
- Cook PF, Schmiege SJ, Mansberger SL, Kammer J, Fitzgerald T, Kahook MY. Predictors of adherence to glaucoma treatment in a multisite study. *Annals of Behavioral Medicine*. 2015; 49:29–39. DOI: 10.1007/s12160-014-9641-8 [PubMed: 25248302]
- Cook PF, Schmiege SJ, McClean M, Aagaard L, Kahook MY. Practical and analytic issues in the electronic assessment of adherence. *Western Journal of Nursing Research*. 2012; 34:598–620. DOI: 10.1177/01935911427153 [PubMed: 22101392]
- Courvoisier DS, Eid M, Nussbeck FW. Mixture distribution latent state-trait analysis: Basic ideas and applications. *Psychological Methods*. 2007; 12:80–104. DOI: 10.1037/1082-989X.12.1.80 [PubMed: 17402813]
- DiClemente CC, Prochaska JO, Fairhurst SK, Velicer WF, Velasquez MM, Rossi JS. The process of smoking cessation: An analysis of precontemplation, contemplation, and preparation stages of change. *Journal of Consulting and Clinical Psychology*. 1991; 59:295–304. DOI: 10.1037/0022-006X.59.2.295 [PubMed: 2030191]
- Doshi RK, Milberg J, Isenberg D, Matthews T, Malitz F, Matosky M, ... Cheever LW. High rates of retention and viral suppression in United States HIV safety net system: HIV care continuum in Ryan White HIV/AIDS program, 2011. *Clinical Infectious Diseases*. 2015; 60:117–125. DOI: 10.1093/cid/ciu722 [PubMed: 25225233]
- Dunbar-Jacob J, Mortimer-Stephens MK. Treatment adherence in chronic disease. *Journal of Clinical Epidemiology*. 2001; 54:S57–S60. DOI: 10.1016/S0895-4356(01)00457-7 [PubMed: 11750211]
- Fleury J. The Index of Readiness: Development and psychometric analysis. *Journal of Nursing Measurement*. 1994; 2:143–154. [PubMed: 7780769]
- Fridhandler BM. Conceptual note on state, trait, and the state-trait distinction. *Journal of Personality and Social Psychology*. 1986; 50:169–174. DOI: 10.1037/0022-3514.50.1.169
- Hann D, Winter K, Jacobsen P. Measurement of depressive symptoms in cancer patients: Evaluation of the Center for Epidemiological Studies Depression Scale (CES-D). *Journal of Psychosomatic Research*. 1999; 46:437–443. DOI: 10.1016/S0022-3999(99)00004-5 [PubMed: 10404478]
- Haynes, RB. Interview on “NIH Research Radio”. Audio podcast. 2010 Apr 23. Retrieved from https://ocplmedia.od.nih.gov/nihradio/20100423NIHpodcast_0108.mp3
- Haynes RB, Ackloo E, Sahota N, McDonald HP, Yao X. Interventions for enhancing medication adherence. *Cochrane Database of Systematic Reviews*. 2008; :CD000011.doi: 10.1002/14651858.CD000011.pub3 [PubMed: 18425859]
- Herzog TA, Blagg CO. Are most precontemplators contemplating smoking cessation? Assessing the validity of the stages of change. *Health Psychology*. 2007; 26:222–231. DOI: 10.1037/0278-6133.26.2.222 [PubMed: 17385974]
- Holm JE, Holroyd KA. The Daily Hassles Scale (Revised): Does it measure stress or symptoms? *Behavioral Assessment*. 1992; 14:465–482.
- Holmes WC, Shea JA. A new HIV/AIDS-targeted quality of life (HAT-QoL) instrument: Development, reliability, and validity. *Medical Care*. 1998; 36:138–154. [PubMed: 9475469]
- Hox, J. *Multilevel analysis: Techniques and applications*. Mahwah, NJ: Erlbaum; 2002.
- Janda LH, Markowski E, Derlega VJ, Nezelek J, McCain N. Daily events and mood state among individuals living with HIV: Examination of the within-persons approach to data collection using daily diary methodology. *Journal of Nursing Measurement*. 2006; 14:116–128. DOI: 10.1891/jnm-v14i2a004 [PubMed: 17086784]

- Kamarck, TW. The diary of ambulatory behavioral states: A new approach to the assessment of psychosocial influences on ambulatory cardiovascular activity. In: Krantz, DS., Baum, A., editors. *Technology and methods in behavioral medicine*. Mahwah, NJ: Erlbaum; 1998. p. 163-185.
- Kazdin, AE. *Research design in clinical psychology*. 4. Needham Heights, MA: Allyn and Bacon; 2003.
- Kiene SM, Simbayi LC, Abrams A, Cloete A, Tennen H, Fishcer JD. High rates of unprotected sex occurring among HIV-positive individuals in a daily diary study in South Africa: The role of alcohol use. *Journal of Acquired Immune Deficiency Syndromes*. 2008; 49:219–226. DOI: 10.1097/QAI.0b013e318184559f [PubMed: 18769345]
- Langness J, Cook PF, Gill J, Boggs R, Netsanet N. Comparison of adherence rates for antiretroviral, blood pressure, or mental health medications for HIV-positive patients at an academic medical center outpatient pharmacy. *Journal of Managed Care and Specialty Pharmacy*. 2014; 20:809–814. DOI: 10.18553/jmcp.2014.20.8.809 [PubMed: 25062074]
- Lewis SJ, Abell N. Development and evaluation of the Adherence Attitude Inventory. *Research on Social Work Practice*. 2002; 12:107–123. DOI: 10.1177/104973150201200108
- Liu H, Golin CE, Miller LG, Hays RD, Beck CK, Sanandaji S, ... Wegner NS. A comparison study of multiple measures of adherence to HIV protease inhibitors. *Annals of Internal Medicine*. 2001; 134:968–977. DOI: 10.7326/0003-4819-134-10-200105150-00011 [PubMed: 11352698]
- Mlodinow, L. *Subliminal: How your unconscious mind rules your behavior*. New York, NY: Random House; 2012.
- Mustanski B. The influence of state and trait affect on HIV risk behaviors: A daily diary study of MSM. *Health Psychology*. 2007; 26:618–626. DOI: 10.1037/0278-6133.26.5.618 [PubMed: 17845113]
- Paterson DL, Swindells S, Mohr J, Brester M, Vergis EN, Squier C, ... Singh N. Adherence to protease inhibitor therapy and outcomes in patients with HIV infection. *Annals of Internal Medicine*. 2000; 133:21–30. DOI: 10.7326/0003-4819-133-1-200007040-00004 [PubMed: 10877736]
- Ptacek JT, Pierce GR, Thompson EL. Finding evidence of dispositional coping. *Journal of Research in Personality*. 2006; 40:1137–1151. DOI: 10.1016/j.jrp.2005.12.001
- Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*. 1977; 1:385–401.
- Reis, HT. Why researchers should think “real-world”: A conceptual rationale. In: Mehl, MR., Conner, TS., editors. *Handbook of research methods for studying daily life*. New York, NY: Guilford; 2012. p. 3-21.
- Reynolds NR. Adherence to antiretroviral therapies: State of the science. *Current HIV Research*. 2004; 2:207–214. DOI: 10.2174/1570162043351309 [PubMed: 15279584]
- Riley WT, Rivera DE, Atienza AA, Nilsen W, Allison SM, Mermelstein R. Health behavior models in the age of mobile interventions: Are our theories up to the task? *Translational Behavioral Medicine*. 2011; 1:53–71. DOI: 10.1007/s13142-011-0021-7 [PubMed: 21796270]
- Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*. 2000; 55:68–78. DOI: 10.1037/0003-066X.55.1.68 [PubMed: 11392867]
- Schwartz, N. Why researchers should think “real-time”: A cognitive rationale. In: Mehl, MR., Conner, TS., editors. *Handbook of research methods for studying daily life*. New York, NY: Guilford; 2012. p. 22-42.
- Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. *Annual Review of Clinical Psychology*. 2008; 4:1–32. DOI: 10.1146/annurev.clinpsy.3.022806.091415
- Stanley MA, Beck JG, Zebb BJ. Psychometric properties of the MSPSS in older adults. *Aging & Mental Health*. 1998; 2:186–193. DOI: 10.1080/13607869856669
- Stanovich, KE. Distinguishing the reflective, algorithmic, and autonomous minds: Is it time for a tri-process theory?. In: Evans, J., Frankish, K., editors. *Two minds: Dual processes and beyond*. New York, NY: Oxford University Press; 2009. p. 55-88.
- Stone AA, Neale JM. New measure of daily coping: Development and preliminary results. *Journal of Personality and Social Psychology*. 1984; 46:892–906. DOI: 10.1037/0022-3514.46.4.892

Terracciano A, Sanna S, Uda M, Deiana B, Usala G, Busonero F, ... Costa PT Jr. Genome-wide association scan for five major dimensions of personality. *Molecular Psychiatry*. 2010; 15:647–656. DOI: 10.1038/mp.2008.113 [PubMed: 18957941]

The White House Office of National Aids Policy. National HIV/AIDS strategy for the United States: Updated to 2020. Washington, DC: Author; 2015. Retrieved from Health Resources & Services Administration website <https://www.aids.gov/federal-resources/national-hiv-aids-strategy/nhas-update.pdf>

FIGURE 1.

Momentary state model of ART adherence behavior, adapted from Cook et al. (2010). In this study, each state-level predictor variable (grey boxes) was entered at Level 1 of a multilevel model, with the outcome of daily behaviorally-measured medication adherence (white box) also at Level 1, and a trait-level measure of the same construct (black box) simultaneously entered at Level 2 of the model. Each predictor was tested separately, with only the state and trait versions of that specific construct included in the model, along with study week as a statistical control for measurement reactivity. Although effect modifier relationships (e.g., in which trait-level characteristics might affect motivation or change the relationship between motivation and adherence) are theoretically possible, these were not a focus of investigation in the current preliminary study of state-level adherence predictors. Similarly, although the model proposes motivation as a mediator of the relationships between the other state-level predictors and ART adherence behavior, mediation was not tested in the current analysis, which focused primarily on differences between state and trait predictors. ART = antiretroviral therapy.

TABLE 1

State- and Trait-Level Measures of Potential Predictor Variables

Type/measure	Sample item	Rating scale ^a	Items	α
State				
Control beliefs	<i>How feeling? Able to handle difficulties?</i>	1 = NO!!	4	.68
DABS, Beliefs Scale ^b		2 = no??		
		3 = yes??		
		4 = YES!!		
Mood	<i>How feeling? Nervous/upset?</i>	1 = NO!!	3	.93
DABS, Mood Scale ^b		2 = no??		
		3 = yes??		
		4 = YES!!		
Stress	<i>Problems with family or friends?</i>	1 = NO!!	6	.67
DHS items ^c		2 = no??		
		3 = yes??		
		4 = YES!!		
Coping	<i>Did you use relaxation (did something with the intention of relaxing)?</i>	1 = NO!!	10	.86
ADC ^d		2 = no??		
		3 = yes??		
		4 = YES!!		
Social support	<i>How feeling? Others willing to be helpful?</i>	1 = NO!!	2	.95
DABS, SS Subscale ^b		2 = no??		
		3 = yes??		
		4 = YES!!		
Motivation	<i>I intend to take my medication as prescribed.</i>	1 = NO!!	6	.79
HMS ^e		2 = no??		
		3 = yes??		
		4 = YES!!		
Trait				
Control beliefs	<i>I am determined to stick with a plan to help me remember to take my medication as prescribed.</i>	1 = none of the time to 7 = all of the time	7	.89
AAI, Self-Efficacy Subscale ^f				
Mood	<i>I was bothered by things that don't usually bother me.</i>	0 = rarely/none of the time to 3 = most/all of the time	20	.81
CES-D ^g				
Stress	<i>In the past 4 weeks, I've been worried about how to pay my bills.</i>	1 = none of the time to 5 = all of the time	24	.75
HAT-QoL ^h				
Coping	<i>I've been getting emotional support from others.</i>	1 = never to 5 = always	28	.78
Brief COPE ⁱ				
Social support	<i>My family really tries to help me.</i>	1 = very strongly disagree to 7 = very strongly agree	12	.94
MSPSS ^j				
Motivation	<i>I think that I need to change some of the ways that I take care of myself.</i>	1 = strongly disagree to 6 = strongly agree	9	.84

Type/measure	Sample item	Rating scale ^a	Items	α
IR ^k				

Note. All α values are from this study. Validity information is available in cited papers. AAI = Adherence Attitude Inventory; ADC = Assessment of Daily Coping; CES-D = Center for Epidemiological Studies–Depression; DABS = Diary of Ambulatory Behavioral States; DHS = Daily Hassles Scale; HAT-QoL = HIV/AIDS Targeted Quality of Life; HMS = Herzog Motivation Scale; HIV/AIDS = human immunodeficiency virus/acquired immune deficiency syndrome; IR = Index of Readiness; MSPSS = Multidimensional Scales of Perceived Social Support; SS = social support.

^aResponse options shown as they appear on the screen or instrument.

^bKamarck (1998).

^cHolm & Holroyd (1992).

^dStone & Neale (1984).

^eHerzog & Blagg (2007).

^fLewis & Abell (2002).

^gHann, Winter, & Jacobsen (1999); Radloff (1977).

^hHolmes & Shea (1998).

ⁱCarver (1997).

^jStanley, Beck, & Zebb (1998).

^kFleury (1994).

TABLE 2

Participant Characteristics

Characteristic	All (N = 87)		Not analyzed (n = 34)		Analyzed (n = 53)	
	n	(%)	n	(%)	n	p ^a
Sex (male)	68	(78.2)	28	(82.4)	40	(75.5) .37
Race/ethnicity						
White, non-Hispanic	43	(49.4)	20	(58.8)	24	(45.3) .32
Latino/Latina	20	(23.0)	6	(17.6)	14	(26.4) .33
African-American	13	(14.9)	4	(11.8)	8	(15.1) .45
Native American	2	(2.3)	1	(2.9)	2	(3.8) .35
Multiracial ^b	6	(6.0)	1	(2.9)	2	(3.8) .37
Other/unspecified	3	(3.4)	2	(5.9)	3	(5.7) .27
Sexual orientation						
Gay or lesbian	44	(50.6)	21	(61.8)	24	(45.3) .26
Heterosexual	28	(32.2)	9	(26.5)	19	(35.8) .33
Bisexual	10	(11.5)	1	(2.9)	8	(15.1) .27
Transgender	1	(1.1)	1	(2.9)	0	(0.0) .45
Gender queer	1	(1.1)	0	(0.0)	1	(1.9) .45
Unspecified/not on list	3	(3.4)	2	(5.9)	1	(1.9) .46
Marital status						
Single	53	(60.9)	25	(73.5)	30	(56.6) .31
Married	9	(10.3)	1	(2.9)	7	(13.2) .42
Divorced	10	(11.5)	2	(5.9)	8	(15.1) .27
Not reported/other	15	(17.2)	6	(17.6)	8	(15.1) .41
Housing						
Living independently	46	(52.9)	19	(55.9)	27	(50.9) .45
Permanently with others	12	(13.8)	2	(5.9)	10	(18.9) .19
Supported living ^c	6	(6.9)	4	(11.8)	3	(5.7) .50
Homeless/unstably housed	23	(26.4)	9	(26.5)	13	(24.5) .45
	M	(SD)	M	(SD)	M	(SD)
Age (years) ^d	40.0	(8.84)	37.9	(8.75)	41.5	7.94 .17

Characteristic	All (<i>N</i> = 87)		Not analyzed (<i>n</i> = 34)		Analyzed (<i>n</i> = 53)		<i>p^a</i>
	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	
Education (years) ^e	13.4	(2.32)	13.8	(2.19)	13.2	2.27	.52
Traits (baseline)							
Control beliefs ^f	6.02	(1.10)	6.09	(1.07)	6.10	0.99	.56
Mood ^g	18.5	(14.3)	15.7	(11.9)	20.2	14.3	.39
Perceived stress ^h	3.70	(1.24)	3.87	(0.85)	3.63	1.25	.69
Coping ⁱ	2.89	(0.54)	3.10	(0.48)	2.78	0.53	.14
Perceived social support ^j	4.43	(1.43)	4.59	(1.39)	4.34	1.43	.65
Motivation for treatment ^k	4.17	(0.97)	4.52	(0.82)	3.99	1.03	.21
States (daily surveys)							
Control beliefs ^l	3.22	(0.74)	3.16	(0.60)	3.16	0.75	.56
Mood ^m	1.83	(0.95)	2.96	(0.83)	1.90	0.99	.61
Perceived stress ⁿ	2.67	(0.66)	2.20	(0.70)	2.68	0.65	.91
Coping ^o	2.44	(0.81)	2.79	(0.68)	2.40	0.83	.73
Perceived social support ^p	3.27	(0.93)	3.17	(0.83)	3.20	0.96	.60
Motivation for treatment ^q	3.67	(0.44)	3.73	(0.38)	3.66	0.43	.87

Note. *SD* = standard deviation.

^aBinomial *z*-test.

^b3 African American/Native American, one Latino/Native American, one Latina/African American, and one endorsed all categories. In the analysis sample, two of the African-American/Native American participants were included and none of the other four multiracial participants.

^cSection VIII or group home.

^dRange: 21–59.

^eRange: 8 (less than high school)–19 (graduate degree).

^fAdherence Attitude Inventory, Self-Efficacy Subscale: possible range 1–7, actual range 1–6.9.

^gCenter for Epidemiological Studies Depression Scale: possible range 0–60, actual range 0–57.

^hHIV/AIDS-targeted Quality of Life worry subscale: possible and actual range both 1–5.

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- j* Brief COPE Scale, total score: possible range 1–5, actual range 1.36–4.42.
- j* Multidimensional Scales of Perceived Social Support: possible range 1–7, actual range 1–6.8.
- k* Index of Readiness: possible range 1–7, actual range 1–6.
- j* Diary of Ambulatory Behavioral States, Thoughts Scale: possible and actual range both 1–4.
- m* Diary of Ambulatory Behavioral States, Mood Scale: possible and actual range both 1–4.
- n* Daily Hassles Scale: possible and actual range both 1–4.
- o* Assessment of Daily Coping: possible and actual range both 1–4.
- p* Diary of Ambulatory Behavioral States, Support Scale: possible and actual range both 1–4.
- q* Herzog Motivation Scale: possible and actual range both 1–4.

TABLE 3

Trait- and State-Level Survey Predictors of Daily MEMS-Based Adherence

Construct	Trait-level prospective predictors				State-level effects on next-day MEMS			
	OR	(SE)	95% CI	p	OR	(SE)	95% CI	p
Control beliefs ^a	1.65	(0.17)	[1.17, 2.35]	.006	1.003	(0.13)	[0.78, 1.29]	ns
Mood ^b	0.98	(0.01)	[0.95, 1.01]	ns	1.33	(0.11)	[1.07, 1.63]	.009
Stress ^b	1.30	(0.16)	[0.93, 1.81]	ns	1.59	(0.35)	[0.81, 3.14]	ns
Coping ^c	0.54	(0.39)	[0.25, 1.19]	ns	0.91	(0.28)	[0.53, 1.58]	ns
Social support ^a	1.25	(0.14)	[0.94, 1.66]	ns	0.90	(0.11)	[0.73, 1.11]	ns
Motivation ^a	0.94	(0.20)	[0.62, 1.42]	ns	1.55	(0.19)	[1.07, 2.24]	.02

Note. *N* = 53. *SE* = standard error; CI = confidence interval.

^a Higher score indicates a more positive result (higher perceived control, more perceived social support, or more motivation for treatment).

^b Higher score indicates a more negative result (more negative mood, or greater stress).

^c Higher score indicates a greater number of coping strategies used, a result that we expected to be positive but that might instead suggest ineffective coping efforts.