Self-Management of Chronic Illness: The Role of 'Habit' vs Reflective Factors in Exercise and Medication Adherence

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Abstract

Background. Non-adherence to health behaviors required for chronic illness self-management is pervasive. Advancing health-behavior theory to include behavioral initiation and maintenance factors, including reflective (e.g. belief- and feedback-based) and automatic (e.g., habit-based) mechanisms of adherence to different treatment-related behaviors could improve non-adherence prediction and intervention efforts.

Purpose. To test behavioral initiation and maintenance factors from an extended Common Sense Self-Regulation theoretical framework for predicting medication adherence and physical activity among patients with Type 2 Diabetes.

Method. Patients (n=133) in an in-person (n=80) or online (n=53) version of the study reported treatment-related (1) barriers, (2) beliefs and experiential feedback (reflective mechanisms of treatment-initiation and short-term repetition), and (3) habit strength (automatic mechanism of treatment-maintenance) for taking medication and engaging in regular physical activity at baseline. Behaviors were assessed via self-reports (n=133) and objectively (electronic monitoring pill bottles, accelerometers; n=80) in the subsequent month.

Results. Treatment-specific barriers and habit strength predicted self-reported and objective adherence for both behaviors. Beliefs were inconsistently related to behavior, even when habits were “weak”. Experiential feedback from behavior was not related to adherence.

Conclusions. Among patients with Type 2 diabetes diagnosis, medication and physical activity adherence were better predicted by their degree of automatic behavioral repetition than their beliefs/experiences with the treatment-actions. Habit strength should be an intervention target for chronic illness self-management; assessing it in practice settings may effectively detect non-adherence to existing treatment-regimens. However, future research and further refining of CS-SRM theory regarding the processes required for such habit development are needed.

Keywords. Commonsense Self-Regulation; Adherence; Exercise; Habit; Type 2 Diabetes

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Self-management of chronic illness requires long-term (i.e. lifelong), regular engagement in multiple treatment-related behaviors, such as taking medications and regular physical activity (PA) (García-Pérez et al., 2013). Non-adherence to these behavioral recommendations for chronic illness self-management is pervasive and the main cause of poor patient outcomes and high healthcare costs (Kravitz & Melnikow, 2004; Van Dulmen et al., 2007). Health behavior theories have had success predicting at least some of the variance in non-adherence to medications and regular physical activity (e.g., Health Belief Model, Rosenstock et al., 1988; Theory of Planned Behavior, Ajzen, 1991; Self-Determination Theory, Deci & Ryan, 2000). However, interventions based on these theories have had some, but little effect in promoting longer-term maintenance of the targeted behaviors (McDonald et al., 2002; Norris et al., 2001).

To advance the predictive utility of these theories, and therefore, the effectiveness of interventions, more work is required in theory development (Rothman, 2004; Phillips et al., 2012) and in evaluation of theory in multiple behavioral and illness contexts (Creer & Holroyd, 1997; Elwood, 2015). Integrated theoretical frameworks that cover factors involved in both behavioral initiation and maintenance are required to understand, predict, and promote long-term behavior change (Phillips et al., 2013; Rothman, 2004; Rothman et al., 2009). Health behavior theories primarily focus on reflective (i.e. consciously processed, deliberative), initiation factors (e.g., social cognitive theories of health behavior; Bandura, 2001); maintenance of behavior is an assumed outcome of successful initiation. For example, if individuals hold favorable beliefs about a behavior and have self-efficacy for performing the behavior, they will intend to engage in the behavior, initiate behavior, and repeat behavior (Ajzen, 1991). However, two areas of research have shown that initiation factors are not sufficient for explaining long-term behavioral engagement: first, maintenance factors differ from initiation factors (Rothman, 2000; Rothman et al., 2009). Second, research has shown that behavioral beliefs and intentions are less predictive of behavior in the long-term, specifically when individuals have developed strong behavioral habits (Danner et al., 2008; Gardner, 2014; but see Rhodes & de Bruijn, 2010). When behavior is habitual, it is automatic and not dependent on reflective factors such as intentions and the beliefs that contribute to these intentions. Therefore, to more fully explain variance in adherence, initiation and maintenance factors should be integrated in theory.

The Common Sense Self-Regulation Model (CS-SRM; Leventhal et al., 2003; Leventhal et al., 2008) has been widely used to understand, predict, and change individuals' self-management practices and outcomes. The current study extends this theory to include behavioral maintenance factors, namely habit strength, which is an automatic mechanism of behavioral repetition. Below, we first explain the extended CS-SRM framework and how its constructs may function differently for different illness contexts; we then describe the current study, the purpose of which is to empirically test key elements of the extended CS-SRM for predicting adherence to two specific treatment-related behaviors—taking medication and engaging in regular physical activity. Both are important behaviors for successful self-management of many chronic conditions, including the current study population of patients with Type 2 diabetes (DiMatteo et al., 2002; García-Pérez et al., 2013).

Extending the Common Sense Self-Regulation Model (CS-SRM)

The CS-SRM is a theoretical framework that describes the primarily reflective, or deliberative processes by which individuals formulate illness- and treatment-related beliefs and behavioral action plans for addressing a health-threat (symptom, illness) and/or its emotional consequences. The left side of Figure 1 depicts the processes described in existing accounts of the CS-SRM (see Mora & McAndrew, 2013; Scott et al., 2012), in which messages regarding a health threat are evaluated and interpreted, leading to an emotional response and formation of an illness representation. The illness representation includes beliefs about the threat's potential label/diagnosis and associated symptoms (identity), causes, consequences, control factors, and duration/timeline. These beliefs influence an individuals' perceived possible treatment-related actions, including seeking care, self-treatment, or other action(s). The illness- and treatment-representations (beliefs about the necessity and consequences of the specific treatment-action; Horne et al., 1999) are theorized to lead to action-planning, initial action, and eventually adherence to treatment-related behaviors over time.

The primary use of the CS-SRM in research and interventions to date has been in predicting and/or manipulating patients' beliefs about their illness and treatment to promote better illness coping and treatment adherence. Patients' illness- and treatment-related beliefs are known predictors of medication adherence in many chronic illness domains, including Type 2 Diabetes (Glasgow et al., 1997; Horne & Weinman, 2002; Mann et al., 2009; Petrie et al., 2007). A recent meta-analysis of the relationships between patients' medication-related necessity beliefs and concerns indicated that both types of beliefs are important for long-term treatment adherence (Horne et al., 2013). However, reflective initiation factors may not be sufficient for explaining variance in long-term treatment adherence, because maintenance factors differ from initiation factors, and behavioral habits, when strong, take over prediction of behavior from more reflective factors, such as beliefs. In fact, some research has shown beliefs do not predict adherence, particularly when adherence is measured objectively (Cooper et al., 2010; Phillips et al., 2013). It is possible that beliefs may play a larger role in some illness contexts compared to others; for example, beliefs may be more predictive of adherence in conditions with greater treatment side effects or when adherence is more variable overall. They may also play a larger role in predicting adherence to other types of treatment behaviors, such as physical activity.

The CS-SRM posits that individuals' illness- and treatment-representations lead to action plans and action. What is included in existing accounts of the CS-SRM but is not widely researched is the role of experiential feedback that patients receive from testing those treatment-related actions (depicted in the middle part of Figure 1) in changing their representations and in contributing to adherence. Gaining feedback through action is theoretically important, because feedback can lead to a coherent system (a general understanding of the illness characteristics and required treatment(s); Phillips et al., 2013) and behavioral repetition. Without feedback that a behavior works as expected, the individual theoretically re-evaluates the health threat's cause, identity, control, timeline, and/or consequences as well as the treatment-action's necessity and consequences. Therefore, this feedback and a coherent system is theoretically required for continued behavioral repetition, and therefore longer-term adherence. Research to test this aspect of the CS-SRM has been mostly limited to static beliefs regarding the illness in general rather than specific treatment-related actions (e.g., from the IPQ-R, Moss-Morris et al., 2002: "I understand my illness, not at all to very much"; see also McAndrew et al., 2008). Phillips et al. (2013) tested whether patients' reports of receiving experiential feedback that their medication works as expected predicted medication adherence, and found that such experiences predicted *intentional* non-adherence but not overall or objectively measured adherence. This construct has not been much studied in a Type 2 Diabetes context, but some researchers have evaluated the benefit of behavioral feedback for optimal adherence: Tanenbaum et al. (2015) interviewed patients in good control of their Type 2 Diabetes and found that patients used their blood glucose meters as a source for feedback on how their self-management efforts were working. Research in the symptom-interpretation literature, which shows that patients use symptom changes to evaluate behavioral success, also supports the importance of experiential feedback and belief-coherence for treatment adherence and illness management (e.g., Siegel et al., 1999). Phillips et al. (2013) suggested that experiential feedback may be more important for determining treatment adherence in illnesses that are symptomatic and/or for behaviors that can provide feedback (unlike with hypertension, where patients cannot tell if their blood pressure is up or is under control with medication; Meyer et al., 1985). Reflective factors in general may better predict intentional (i.e. skipping a dose, decreasing or increasing a dose) than unintentional non-adherence (i.e. forgetting; Phillips et al., 2013).

With a coherent system, it is possible that a person's action plans may change to strategies for behavioral maintenance (Brooks et al., 2015) but remain reflective, or deliberative (e.g., satisfaction with continued behavioral outcomes, Fleig et al., 2013). With repetition in stable contexts, however, the behavior may shift to *automatic repetition* through habitual action (Rothman et al., 2009). Habitual action does not require reflection or deliberation on the reasons for doing a behavior, because habits are automatically triggered by conditioned contextual cues (Wood & Neal, 2007; Gardner, 2014; e.g. a person may automatically take his medication after brushing his teeth in the AM and PM). The right side of Figure 1 depicts this added construct to the existing CS-SRM constructs. Habits are theoretically important for long-term adherence, because they do not tax cognitive and self-regulatory resources, are not subject to tempting behavioral alternatives, and are the default behavior (Aarts et al., 1997; Danner et al., 2008). Indeed, habits are more likely to be maintained than non-habits (Orbell & Verplanken, 2010; Phillips et al., 2013), and habit strength has been found to predict behavior in different domains, including dietary behavior (Wiedemann et al., 2014), physical activity (Gardner et al., 2012); and medication adherence (Bolman et al., 2011; Phillips et al. 2013). The degree to which behavioral habit strength predicts treatment adherence among patients with Type 2 Diabetes has not been studied, to our knowledge; further, the relative importance of habit strength for predicting medication adherence versus a more complex behavior, such as physical activity, within the same population has not been studied in any illness-management or -prevention context. Phillips et al. (2013) found that habit strength was the strongest predictor of objective and self-reported medication adherence, suggesting interventions should focus on habit development. However, they concluded that more research is needed in different illness-contexts, such as those that are symptomatic, have greater treatment complexity (requiring more complex medication regimens but also different treatment behaviors), and allow for direct experiential feedback from treatment-related behaviors.

The Current Study

We have outlined above how automatic factors can extend the CS-SRM to explain behavioral maintenance, and we have described the process by which an individual may move from reflective formation of illness and treatment beliefs to automatic enactment of treatment-actions (Figure 1). The current study focuses on taking those CS-SRM constructs *specific to a treatment-related behavior* and testing their importance for predicting non-adherence to that behavior (i.e. using the theoretical constructs from the extended CS-SRM to predict adherence and to evaluate the behavior/treatment-specific and illness-specific roles of these factors for predicting adherence). Namely, the current study evaluates the importance of (1) treatment-related beliefs; (2) experiential feedback that the behavior works as expected; and (3) treatment-related habit strength for predicting variance in both medication adherence and physical activity.

The degree to which the tested theoretical constructs, both reflective and automatic, predict treatment adherence (i.e. their relative importance) may depend on the illness-context and on the target behavior. The current study focuses on Type 2 Diabetes, which has a very high and climbing prevalence and a significant impact on healthcare and patient quality of life (Knowler et al., 2002). Type 2 Diabetes presents different characteristics than hypertension in that it can be symptomatic, requires daily management with feedback from a monitor, and involves multiple treatment behaviors for successful management (García-Pérez et al., 2013). When a condition is symptomatic and requires multiple treatment-related behaviors of varying complexity, there may be differences in the influence of the theoretical factors on adherence and illness self-management, which affects our proposed theoretical factors in long-term adherence. First, beliefs may be more predictive of treatment adherence when a treatment has greater likelihood of negative side effects; compared to hypertension medication, medications for Type 2 Diabetes and physical activity have potentially more severe and frequent side effects. Second, the role of experience (i.e. experiential feedback) may be more important for management of a symptomatic condition, where feedback is possible and frequent. Furthermore, experience (experiential feedback) may be more important for a behavior that requires more time and effort (i.e. the individual may need to be more convinced through experience to continue that behavior than for a simple behavior that has no cognitive or time costs)—specifically exercise versus taking a medication. Lastly, the role of habit may depend on the complexity of the treatment-related behavior. When a behavior is relatively simple, such as taking one pill once a day, then context cues may be sufficient to trigger a habit and maintain adherence in the long-term. For complex behaviors, such as physical activity, beliefs and experiential feedback may remain important, along with a degree of habit strength, in predicting behavioral maintenance. That is, although the theoretical process for behavior initiation to maintenance may be universal, the factors' *relative* importance for adherence may differ for different target behaviors.

Specifically, the study tests the following hypotheses:

(1) The primary hypothesis is that the two reflective repetition factors (treatment-specific beliefs and experiential feedback; behavior-specific factors in the left and middle parts of Figure 1) and the automatic repetition factor (treatment-specific habit strength, right part of Figure 1) will significantly and uniquely predict adherence to medication and regular physical activity.

(2) Regarding the *reflective* factors in behavioral initiation and repetition, we hypothesize the following: (a) treatment-specific beliefs will more strongly predict adherence when habit strength is low vs high (i.e. habit strength will moderate the relationship between beliefs and adherence); and (b) treatment-specific beliefs and experiential feedback will predict *intentional* more-so than *un*intentional non-adherence to medication ($R_1 > R_2$ in Figure 2a).

(3) Regarding *automatic* processes of behavioral repetition, or treatment-specific habit strength, we hypothesize the following: (a) medication-related habit strength will more strongly predict objectively-measured dose-timing adherence (% of daily doses taken on time, within a two-hour window—indicating presence of a stable context cue for action) compared to overall adherence (% of days prescribed number of doses were taken; action may be reflective and not tied to context cue); and (b) medication-related habit strength will more strongly predict *unintentional* compared to intentional non-adherence to medication ($R_4 > R_3$ in Figure 2a).

(4) Lastly, the relative influence of habit strength compared to reflective factors (beliefs and experiential feedback) on medication adherence is expected to be greater than that for physical activity (i.e. even if habit strength is the strongest predictor for both behaviors in absolute terms, its relative importance compared to that of the reflective factors is expected to be

greater for medication adherence than for physical activity). In Figure 2b, the difference between R_7 and R_5 is expected to be greater than the difference between R_8 and R_6.

Method

Participants

Participants in the Washington D.C. sample (n=99) and the Milwaukee, Wisconsin sample (n=34) were patients with diagnoses of Type 2 Diabetes recruited from endocrinology clinics in their respective cities. The sample-specific demographics are provided in Table 1. In the total sample of 133 participants, the average age was 56.96 years (*SD* = 12.04), the average length of time since diagnosis with Type 2 Diabetes was 10.26 years (*SD* = 12.85), 62% were female, 92% identified as Non-Hispanic, 41% identified as Caucasian/White race, 52% identified as African/Black race, 7% identified as other minority or multi-racial, 52% had a 4-year college degree/equivalent or higher level of education, and 79% had been on their current diabetes medication for at least 1 year (with modal duration = 1-3 years on the medication).

We conducted a power analysis prior to the start of the study to estimate the required sample size to detect a small-to-medium effect (by convention; Faul, Erdfelder, Lang, & Buchner, 2007) in the R^2-change when "experiential feedback" was added as a predictor of adherence after treatment-related beliefs and barriers were first entered as predictors, and for the R^2-change when "habit strength" was added as a final predictor in the hierarchical linear regression (these analyses are for the primary hypotheses for the two target behaviors). The effect size estimate ($f^2 = 0.09$ or *partial* $R^2 = 0.08$) came from existing literature that tested similar hypotheses (Phillips et al., 2013) in a different illness-context. The power analysis, conducted with G*Power (Faul et al., 2007), with power = 0.90, and $\alpha = .05$ yielded a required sample size estimate of 119. Resources limited the number of participants who could complete the in-person version of the study (n=80); an online-only version of the study was used to increase the sample size for all analyses except those using objective outcomes (n=133).

Procedure

Inclusion criteria were the following: the patient had to (1) have been seen at the clinic within the past calendar year (to eliminate patients in the system who were no longer patients at the practice), 2) be 18 years of age or older, 3) be on pill-form medication for treatment of Type 2 Diabetes, and 4) be proficient in speaking English. Patients were identified in the clinics' medical records to meet these criteria; those who met these eligibility criteria were sent letters inviting them to participate in the study. They were given the option to call study personnel, to provide their contact information in a postage-paid envelope so that the study personnel could contact them, or to email study personnel with questions about the study or to indicate their interest. Study personnel in Washington D.C. also recruited patients for the study in-person, at the endocrinology clinic; eligible patients were first identified by clinic staff and then approached by study personnel. The volunteer rate via recruitment letters and in-clinic recruitment was approximately 11%. Although low, these response rates are comparable to other clinic populations with volunteer samples (Andersen et al., 2010; Phillips et al., 2013). All procedures were approved by the relevant institutions' human ethics committees.

In-person study version. After indicating interest, patients were scheduled for a 1- to 1.5- hour baseline appointment at which they filled out the baseline survey on a computer in a study office and given an electronic monitoring pill bottle and a Fitbit to use for the subsequent month. Participants were compensated with 20 dollars cash at the end of the baseline visit. After the month of using the devices, participants self-reported physical activity and medication adherence in the preceding month and mailed back the devices in pre-paid envelopes or returned them in person. They were then mailed a check for 30 dollars.

Online-only study version. After indicating interest, patients were emailed a link to the same baseline survey (on Qualtrics.com) that in-person study participants completed. One month after completing the baseline survey, participants were sent a second survey link and then mailed a check for 25 dollars.

Measures

Demographics and information regarding duration of Type 2 Diabetes diagnosis and treatment were evaluated along with the following scales. Descriptive statistics, internal consistency values, and bivariate correlations between study variables are in Tables 2 and 3.

Medication adherence barriers. Patients reported barriers to taking medications on the Brief Medication Questionnaire (Svarstad et al., 1999); e.g., “My medication causes side effects” and “It is hard to pay for the medication”: None (=1), a little (=2), a lot (=3). Seven items were averaged to represent the variable, with moderate internal consistency (α=0.61). The low alpha may be due to the fact that barriers represent a formative construct, which is not expected to have high internal consistency (experience of one type of barrier does not mean other barriers are more likely to be experienced; Jarvis et al., 2003); further, relationships between this type of construct and other variables is not influenced by measurement reliability error, and so the low alpha should not negatively affect the tested relationships.

Medication-related beliefs. Beliefs were measured using the Specific Necessity Beliefs and Specific Concerns subscales of the Beliefs about Medicines Questionnaire (BMQ; Horne et al., 1999). Example items are “My health, at present, depends on this medication” and “This medication disrupts my life”, respectively; answer options ranged from strongly disagree (=1) to strongly agree (=5). Scores on the variables are averages, with higher values indicating greater necessity beliefs and greater concerns about the medication (α=0.85 and 0.82, respectively).

Experiential feedback from medication. Patients responded to, “Have you noticed the positive benefits of the medication? (Yes/No)” and “Have you experienced any solid/convincing evidence that the diabetes medication does what it is supposed to do”: No evidence (=1), some evidence (=2), solid evidence (=3). The composite variable is an average of the patients’ standardized scores on these two items (α=0.76).

Medication-taking habit strength. Patients reported the degree to which they take their medications automatically with the Self-Report Behavioral Automaticity Index (SRBAI; Gardner et al., 2012), which is a widely used subscale of the Self-Report Habit Index (Verplanken & Orbell, 2003). An example item is, “Taking this medication is something I do automatically”: strongly disagree (=1) to strongly agree (=5). The variable is an average of 4 items (α=0.84).

Physical activity (PA) adherence barriers. Patients self-reported barriers to regular PA on the 9 barriers items of the Exercise Benefits/Barriers Scale (Sechrist et al., 1985; e.g., “Exercising takes too much of my time” and “It costs too much money to exercise”). Answers ranged from strongly disagree (=1) to strongly agree (=5), and items were averaged (α=0.88).

PA-related beliefs. Items were adapted for measuring patient beliefs in the necessity of and concerns with physical activity as a treatment for diabetes. Since this is a novel use of the scales that have been evaluated only in a medication-adherence context, we list all the items used to measure PA-related beliefs here, all from strongly disagree (=1) to strongly agree (=5). Necessity beliefs: “My health, at present, depends on my getting exercise,” “My life would be impossible if I did not exercise,” “Without getting exercise I would be very ill,” “My health in the future will depend on my getting exercise”, “Exercising protects me from becoming worse” (α =0.81). Concerns: “Having to exercise worries me”, “I worry that exercising is actually bad for me,” “Having to exercise disrupts my life”, “I worry that I might get injured when I exercise”, and “The reasons for exercising are a mystery to me” (α=0.75).

Experiential feedback from PA. The same two items were used as for experiential feedback from medication, but with “exercise” substituted for “medication” (α=0.66).

PA-related habit strength. The SRBAI was used as for medication-taking habit strength but with the item stem, “Exercising is something I do…” (4 items; α=0.95).

Medication adherence. Patients self-reported total adherence, intentional non-adherence and unintentional non-adherence at one-month follow-up using the Medication Adherence Report Scale (MARS; Horne, 2004). Unintentional non-adherence was assessed with the item, “I forget to take my medication”: Never (=1) to always (=5). Intentional non-adherence was assessed with the average of four items such as “I decide to miss out on a dose”: Never (=1) to always (=5). The total adherence scale is an average of the five items, scored so that higher values indicate greater adherence (α=0.85).

For a subset of participants, electronic monitoring pill bottles (Medication Event Monitoring System, MEMS, MWV/Aardex Corp) captured the % of days (out of 30) that the patient took the prescribed number of doses (one or two) and the % of doses taken “on time”, or within a two-hour window determined by the time they took their medication most of the time or by the time they were told to take the medication by their provider (if applicable).

PA frequency. Physical activity was self-reported at follow-up as the number of PA sessions in the previous week (PA defined as 30 minutes moderate to vigorous intensity activity throughout the day, in at least 10 minute “bouts”). For a subset of the participants, “Fitbit” (accelerometer) measurement of average steps per day during the month of study was used. The only missing data in the study was a result of participants forgetting to wear their Fitbit on a particular day. All participants wore their Fitbits (verified via software, Fitabase, Fitabase.com) on at least 75% of the applicable days, and so an average number of daily steps was calculated to represent the variable, from available days, for all participants.

Analysis Overview

Before conducting the analyses to test the hypotheses, the data was evaluated for range of adherence to both medications and regular physical activity, to detect outliers and potentially influential control variables, to assess the construct validity of the predictors in the current sample, and to evaluate assumptions of regression analyses.

To analyze Hypothesis 1 regarding the predictive utility of each theoretical factor in adherence, we conducted hierarchical linear regression with treatment-specific barriers, beliefs, experiential feedback, and habit strength entered as predictors in separate steps of the model. Four regressions were run in total, one for each of the separate outcomes: self-reported and objective measures of both medication adherence and physical activity.

To analyze Hypothesis 2a, regarding the predictive utility of treatment-specific beliefs in adherence when habit strength is low vs high, we conducted hierarchical linear regression with the interaction between beliefs and habit strength predicting each adherence outcome incrementally to the mean-centered, behavior-specific beliefs and habit strength terms, separately for medication and physical activity.

To analyze Hypotheses 2b, 3a, and 3b, which all regard the relative strength of relationships between the theorized predictors and different adherence outcomes (e.g., intentional versus unintentional), we used correlated-correlation analyses (Meng et al., 1992), also known as Steiger's Z-test. This test is like Fisher's Z test for comparing the difference between two correlation coefficients but recognizing that the two correlations are not independent of each other (they are themselves correlated). In order to calculate a correlation between the reflective factors and adherence and compare it to the correlation between habit strength and adherence, we determined the multiple R for the two reflective factors (beliefs and experiential feedback; see Figures 2a and 2b).

Lastly, Hypothesis 4, regarding the relative importance of automatic and reflective factors for medication adherence versus PA adherence was tested by comparing the 95% confidence intervals for the difference in adjusted R for habit strength and reflective factors in predicting medication adherence compared to PA. That is, adjusted R was determined for each relationship shown in Figure 2b, and Steiger's Z test was then used to determine the 95% CI of the difference between R_7 and R_5 and between R_8 and R_6. The 95% CI for R_7-R_5 was then compared to the 95% CI for R_8-R_6 to see if R_7-R_5 > R_8-R_6.

Results

Preliminary Analyses

Study correlations and descriptive statistics are reported in Tables 2 and 3. Mahalanobis distances did not indicate the presence of any substantial multivariate outliers. Standardized residual plots verified normality assumptions except for one analysis, for which one individual had a standardized residual value of -7.68; further inspection of univariate outliers indicated this patient, a participant in the online version of the study, was an outlier on self-reported medication adherence (MARS; standardized score of -5.95) and so was excluded from relevant analyses. No other univariate outliers (defined as |Z| > 3.0) were detected.

Medication- and diagnosis- duration were unrelated to the adherence outcomes. Age was significantly related to self-reported total medication adherence ($r(130)=0.29$, $p=0.001$) and marginally related to MEMS-measured adherence (%days adherent; $r(79)=0.21$, $p=0.06$). Gender was significantly related to self-reported PA frequency ($r(127)=-0.28$, $p=0.001$) and marginally related to Fitbit daily steps ($r(75)=-0.22$, $p=0.06$), with women engaging in physical activity more than men. Education level was significantly related to patients' self-reported medication adherence ($r(128)=0.18$, $p=0.04$), self-reported PA frequency ($r(127)=0.26$, $p=0.003$), and Fitbit daily steps ($r(74)=0.25$, $p=0.03$). Hispanic ethnicity was significantly related to self-reported medication adherence ($r(123)=0.20$, $p=0.03$). Lastly, minority race status was significantly related to self-reported medication adherence ($r(130)=-0.26$, $p=0.003$) and MEMS-measured adherence ($r(79)=-0.29$, $p=0.009$). Results of the multivariate tests, below, are provided with and without these control variables included in analyses.

Regarding bivariate relationships between the theoretical predictors: medication-related experiential feedback was significantly related to participants' necessity beliefs and concerns regarding the medication ($r(131)=0.37$, $p<0.001$, and $r(131)=-0.25$, $p<0.01$, respectively). Medication-taking habit strength was only related to medication-related barriers ($r(131)=-0.21$, $p<0.05$). PA-related experiential feedback was significantly related to participants' necessity beliefs and concerns regarding PA ($r(132)=0.36$, $p<0.001$, and $r(132)=-0.23$, $p<0.01$, respectively). PA-related habit strength was related to PA barriers ($r(132)=-0.40$, $p<0.001$); to necessity beliefs and concerns regarding PA ($r(132)=0.37$, $p<0.001$, and $r(132)=-0.33$, $p<0.001$, respectively); and to PA-related experiential feedback ($r(132)=0.27$, $p<0.01$). These relationships provide support for the construct validity of the measures—i.e., that they are capturing the constructs intended, in the current sample.

Tests of the Hypotheses

Hypothesis 1. The hypothesis that treatment-specific beliefs, experiential feedback, and habit strength would each predict significant, incremental variance in adherence for both medication and physical activity was partially supported. First, regarding predictive validity of the treatment-specific beliefs: counter to expectations, the medication-specific necessity beliefs were not predictive of self-reported or objective medication adherence. Medication-specific concerns were only predictive of *self-reported* total medication adherence (MARS; in the final model, specific concerns B=10.09, $SE\ B$=0.04, β =-0.17, p<0.05) but not when demographic control variables were included. Further, concerns about medication were not related to objective medication adherence. The relationship between physical-activity-related beliefs and adherence depended on the type of belief and the outcome: Participants' specific necessity beliefs regarding physical activity (PA) predicted self-reported PA frequency incrementally to PA-related barriers: in the model with only PA-related barriers and the beliefs constructs as predictors, specific necessity beliefs had B=0.65, $SE\ B$=0.24, β =0.23, p<0.01. This effect was marginally significant in the final model and significant in the final model if control variables (gender and education) were included (see Table 6). However, specific necessity beliefs did not predict Fitbit daily steps, but specific concerns regarding PA did, with and without control variables (in the final model without control variables, B=-1733.50, $SE\ B$=644.10, β =-0.36, p<0.01).

Second, regarding the role of experiential feedback in determining long-term adherence, the results were counter to our expectations: experiential feedback that the treatment worked as expected was not predictive of any adherence outcome for either target behavior, regardless of inclusion of the demographic control variables.

Third, regarding treatment-specific habit strength, results supported the hypothesis. Habit strength consistently predicted incremental variance in the measured outcomes, both self-reported and objectively measured, for both target behaviors: Medication-taking habit strength predicted significant incremental variance in self-reported total medication adherence (MARS); in the final model, *B*=0.15, *SE B*=0.04, β =0.32, $p<0.001$. PA-related habit strength significantly predicted self-reported PA frequency in the final model with and without control variables included in the analysis (see Table 6; in the final model without control variables, habit strength had *B*=0.66, *SE B*=0.17, β =0.35, $p<0.001$). PA-related habit strength significantly predicted Fitbit daily steps in the final model, with and without control variables included.

Regarding barriers, medication-related barriers significantly predicted self-reported total medication adherence (MARS) in all steps of the regression (in the final model, *B*=-0.45, *SE B*=0.13, β =-0.27, $p<0.01$; see Table 4). When control variables (age, racial minority status, ethnicity, and education level) are included in a step prior to medication-related barriers, barriers are no longer significantly predictive of MEMS-measured adherence. PA-related barriers significantly predicted self-reported PA frequency in all steps of the regression (in the final model, PA-related barriers had *B*=-0.62, *SE B*=0.29, β =-0.21, $p<0.05$; with control variables in the regression, *B*=-0.54, *SE B*=0.28, β =-0.18, $p<0.05$). PA-related barriers was a significant predictor of Fitbit daily steps in the final model, with control variables included (without control variables, PA-related barriers was marginally predictive of the outcome; see Table 7).

Hypotheses 2a and 2b, regarding reflective behavioral factors. Hypothesis 2a, regarding the particular importance of treatment-specific beliefs for predicting adherence when treatment habit strength was low compared to high was not supported for either target behavior, for either type of belief (necessity or concerns): A test of the interaction of patients' specific *necessity beliefs* for medication and medication-taking habit strength was not significant in predicting self-reported medication adherence (MARS) at follow-up (interaction term: *B*=-0.01, *SE B*=0.05, β=-0.02, *p*=0.84) or MEMS-measured adherence (interaction term: *B*=3.776, *SE B*=4.09, β=0.10, *p*=0.36). Likewise, the interaction between patients' specific *concerns* regarding medication and medication-taking habit strength was not significant in predicting self-reported medication adherence (MARS) at follow-up (interaction term: *B*=0.05, *SE B*=0.05, β=0.09, *p*=0.29) or MEMS-measured adherence (interaction term: *B*=0.83, *SE B*=3.27, β=0.03, *p*=0.80). A test of the interaction of patients' specific *necessity beliefs* for PA and PA-related habit strength was not significant in predicting self-reported PA frequency at follow-up (interaction term: *B*=-0.16, *SE B*=0.21, β=-0.07, *p*=0.44) or Fitbit-daily-steps (interaction term: *B*=-380.54, *SE B*=469.39, β=-0.10, *p*=0.42). Likewise the interaction between patients' specific *concerns* regarding PA and PA-related habit strength was not significant in predicting self-reported PA (interaction term: *B*=0.09, *SE B*=0.21, β=0.03, *p*=0.67) or Fitbit-daily-steps (interaction term: *B*=-128.56, *SE B*=397.59, β=-0.04, *p*=0.75). Including control variables did not alter the results.

Hypothesis 2b, regarding the role of reflective factors in predicting intentional vs unintentional non-adherence to medication was supported: the multiple adjusted R for the reflective variables (beliefs and experiential feedback) predicting intentional non-adherence (R_1=0.23) was significantly greater than the adjusted R for the reflective variables predicting unintentional non-adherence (R_2=0.06). With intentional and unintentional non-adherence correlating with each other at *r*(130)=0.54, the Z-statistic=2.0 for the difference between R_1 and R_2; this corresponds to a 95% confidence interval for R_1-R_2=(0.003, 0.34). Reflective factors were more predictive of intentional than unintentional non-adherence to medication.

Hypotheses 3a and 3b, regarding automatic behavioral repetition (habit strength). The hypothesis that patients' medication-taking habit strength would more strongly predict MEMS-measured % of doses taken on time than MEMS-measured % of days adherence (prescribed doses taken at any time during the day) was not supported. The correlation between habit strength and % doses on time ($r(79)=0.40$) was not significantly greater than the correlation between habit strength and % days adherence ($r(79)=0.37$). The two MEMS measures correlated at $r(79)=0.81$; the Z-statistic was -0.51 for the difference between their correlations with habit strength, which corresponds to a 95% confidence interval=(-0.19,0.11).

Further, the hypothesis that habit strength would more strongly predict unintentional non-adherence than intentional non-adherence was not supported: the multiple adjusted R for habit strength predicting unintentional non-adherence ($R_4=0.40$) was not significantly greater than the adjusted R for habit strength predicting intentional non-adherence ($R_3=0.33$). Intentional and unintentional non-adherence correlated at $r(130) = 0.54$; the Z-statistic was 0.95 for the difference between R_4 and R_3, corresponding to a 95% confidence interval for R_4-R_3=(-0.09, 0.26). Habit strength was equally predictive of intentional as unintentional non-adherence.

Hypothesis 4, regarding the relative role of reflective and automatic factors for medication adherence versus PA. The hypothesis that habit strength would be relatively more important for predicting medication adherence than PA, compared to reflective factors, was not supported: The adjusted R values in Figure 2b for self-reported outcomes were the following: $R_5=0.21$, $R_6=0.33$, $R_7=0.40$, and $R_8=0.44$. The adjusted R values in Figure 2b for objective outcomes were the following: $R_5=0.10$, $R_6=0.28$, $R_7=0.36$, and $R_8=0.29$. The hypothesis was that R_7-R_5 (= 0.18 for self-reported outcomes and 0.27 for objective outcomes) would be significantly greater than R_8-R_6 (= 0.11 for self-reported outcomes and 0.01 for objective outcomes). Although the actual values indicate support for the hypothesis ($0.18 > 0.11$ and $0.27 > 0.01$), the 95% confidence intervals for all four differences included 0, meaning the confidence intervals for R_7-R_5 and R_8-R_6 overlapped for both self-reported and objective outcomes. These results indicate that the relative importance of automatic and reflective factors for treatment adherence are the same for both types of behaviors.

Discussion

The CS-SRM describes how an individual determines a course of action for handling a health-related threat. The extended CS-SRM, as depicted in Figure 1, describes how treatment-related actions may be repeated through reflective means (i.e. because an individual has experienced that the behavior meets expectations and his/her beliefs are that the behavior has more advantages than disadvantages, etc) or may be repeated through automatic processes, through habitual action or response to conditioned cues. Adherence levels in a group of individuals are therefore multi-determined; some may be adherent because they intend to adhere due to their beliefs in the necessity of the treatment, and some may be adherent because they engage in the treatment without thinking (automatically). Treatment repetition may be determined by reflective factors, if not habitual, or may be habitual, if not reflective. Therefore, in predicting adherence overall, we expected each of the reflective and automatic factors of behavioral repetition to be significant predictors of adherence to both medication and physical activity (PA) (Hypothesis 1). We also evaluated potential behavior-specific and illness-specific roles of these factors in adherence, in tests of Hypotheses 2-4.

In the test of this primary hypothesis (i.e. that the three measured constructs would predict unique variance in patient adherence to medication and PA), only behavior-specific habit strength was a consistently significant predictor of self-reported and objective adherence measures of behavior, with and without control variables included in the analyses. Beliefs were inconsistently related to adherence, and relationships depended on the measure (self-reported or objective), whether control variables were included, and the target behavior: specific medication concerns predicted only self-reported medication adherence, and only when control variables were not included in the model. Moreover, specific PA-concerns predicted only objective PA, and not self-reported PA frequency, whereas specific PA necessity beliefs predicted only self-reported but not objective PA. As depicted in the left side of Figure 1, when behavior is not strongly habitual and therefore is more reflective, behavioral repetition (adherence) should be determined at least partially by patients' beliefs. CS-SRM theory and prior evidence suggest that this is so, but the current results match those of Phillips et al. (2013) who found that beliefs did not significantly predict adherence, even when behavior was weakly/not habitual. Results from the tests of Hypothesis 2a in the current study also suggest that reflective factors are not more important when habit strength is low. These results are not in line with existing research regarding the interaction of behavioral intentions and habit strength for predicting future behavioral engagement (Gardner, 2014). The current results do not mean that patients' beliefs about their medications and PA are unimportant factors in adherence; beliefs at least predicted intentional non-adherence. Further, two limitations may have influenced the strength of observed relationships between the reflective factors and adherence: the range of adherence may have been restricted in the current sample of volunteers and the duration of treatment may have been too long to pick up "behavior initiation and initial repetition" processes.

Regarding the role of experiential feedback for predicting behavior, patients' reported experiences of treatment/behavior effectiveness did not predict treatment-related behavior in the current sample of patients with Type 2 Diabetes, despite expectations that they would. While this might call into question the validity of the measures for experiential feedback, the psychometric assessment of these measures in the current study suggested that they were at least related as expected to the other predictor variables (beliefs and habit strength). Existing literature (Phillips et al., 2013) has suggested that experiential feedback may be more likely to influence treatment adherence in symptomatic conditions/treatments than in illness contexts where little experiential feedback is possible (asymptomatic illness and/or treatments without noticeable side effects of benefits). The current study indicates that experiential feedback is no more predictive of adherence in patients with Type 2 Diabetes than in patients with hypertension.

It is possible that beliefs and experiences play a more important role when patients are just beginning a new treatment, and habit strength takes over the self-management system rather quickly with behavioral repetition. While the current sample had a greater range of medication duration than observed in the Phillips et al. (2013) sample, the modal duration was still 1-3 years, which may be beyond the time when beliefs are most important for adherence. Counter to previous literature (Phillips et al., 2013) and expectations, habit strength equally predicted medication dose-timing (% doses taken on time) as % of days adherence to the number of doses (i.e. regardless of time taken); and, habit strength equally predicted intentional and unintentional non-adherence. Lastly, habit strength and reflective factors were not differentially important for PA compared to medication adherence, indicating behavioral complexity may not influence the degree to which behavioral maintenance is determined by automatic factors.

Potential limitations of the current study include the following: first, the validity of self-reported habit strength has been called into question (Hagger et al., 2014), since *automatic* behaviors are difficult to reflect on and report accurately. However, others have shown that participant-reported behavioral automaticity predicts behavioral frequency and maintenance incrementally to past behavioral frequency (Orbell & Verplanken, 2010), indicating the measure captures the unique aspects of behavioral automaticity from behavioral frequency. Further, since the same measure has been used in different published studies, the results of these studies are still comparable to each other and therefore of use to researchers and practitioners. Future research should evaluate the basic theoretical role of self-reported behavioral automaticity in actual behavioral automaticity in addition to future research designed to develop interventions to promote “habit”, or whatever is captured by self-reports of behavioral automaticity—since the predictive capability of these reports are garnering strong evidence. Second, although there was variability in patients’ adherence to medications and engagement in PA, at a rate comparable to other published literature (Andersen et al., 2010; Phillips et al., 2013), those who volunteered for the study were likely more adherent than those who did not respond to the recruitment letters. Recruiting an inception sample would allow for a better, longitudinal assessment of the theoretical factors in determining long-term adherence, capturing those who quit treatment early or vary in adherence over time. Lastly, although acceptable for a two-item measure, the low internal consistency of the experiential feedback items suggests further measure development is required. The relatively low reliability may have prevented the detection of true relationships.

The current study, along with existing evidence in a hypertension context (Phillips et al., 2013) indicates that the added habit-strength construct to the CS-SRM theoretical framework is a useful addition for predicting behavioral maintenance to multiple types of treatment behaviors and in varied illness contexts—simple and complex treatments as well as asymptomatic and symptomatic conditions. Researchers could evaluate this extended CS-SRM and the relative importance of reflective and automatic behavioral repetition factors in predicting adherence to different (and multiple) treatments in different illness contexts. This would allow us to further evaluate the usefulness and accuracy of the extended CS-SRM for explaining self-management of chronic conditions that vary in severity of consequences, experience of symptoms, availability of monitor-based and symptom-based feedback, and complexity of treatment-regimen.

Although the current study evaluated single treatment actions, more complex management systems are possible and fit within the CS-SRM. For example, future research could evaluate sets of management actions that a patient uses to manage an illness. The analyses would test the importance of the theoretical constructs for overall management rather than adherence to one treatment-related behavior in isolation. Comorbid chronic conditions also would influence how an individual maintains his/her health overall. And behavioral maintenance through habitual action could be a complex system of context-cues being determined by patients' regular management routines; for example, the successful manager of Type 2 diabetes could have a habit of checking his/her blood glucose at key times during the day and respond relatively automatically with one treatment action from a "toolbox" of treatment actions, based on prior experiential feedback regarding which action works best in specific contexts.

Possible ramifications of the current research findings for practice are twofold: first, practitioners may be able to ask patients about their treatment-related habit strength in order to get a good sense of their adherence to existing medications/PA. Second, researchers could test the relative effectiveness of behavioral interventions to promote long-term adherence by focusing on habit development instead of, or in addition to, interventions that focus on beliefs and experiential feedback. While unfavorable beliefs may hinder adherence to treatment behaviors, the current study indicates that interventions may be better suited to focus on the routinization of treatment behavior and the removal of structural barriers for promoting long-term PA and medication adherence. Medical providers or close supportive others could potentially play a role in implementing interventions to reduce barriers and to promote routinization (Nagelkerk et al., 2006; Williams et al., 2004).

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Figure 1

Figure 1 illustrates the Common Sense Self-Regulation Model, extended to (1) specify the role of experiential feedback from treatment-related action in continued repetition of the behavior and (2) include automatic behavioral repetition, or behavioral habit strength, as a treatment adherence factor important for long-term maintenance of treatment-related behavior.

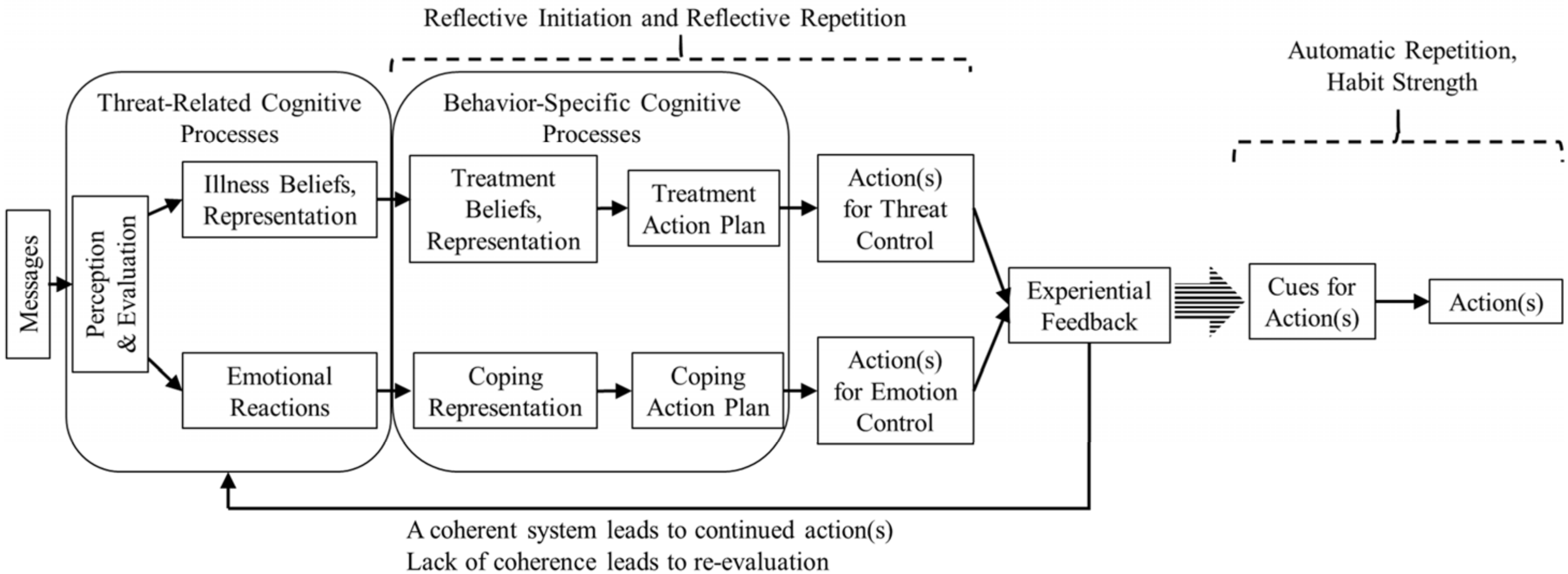
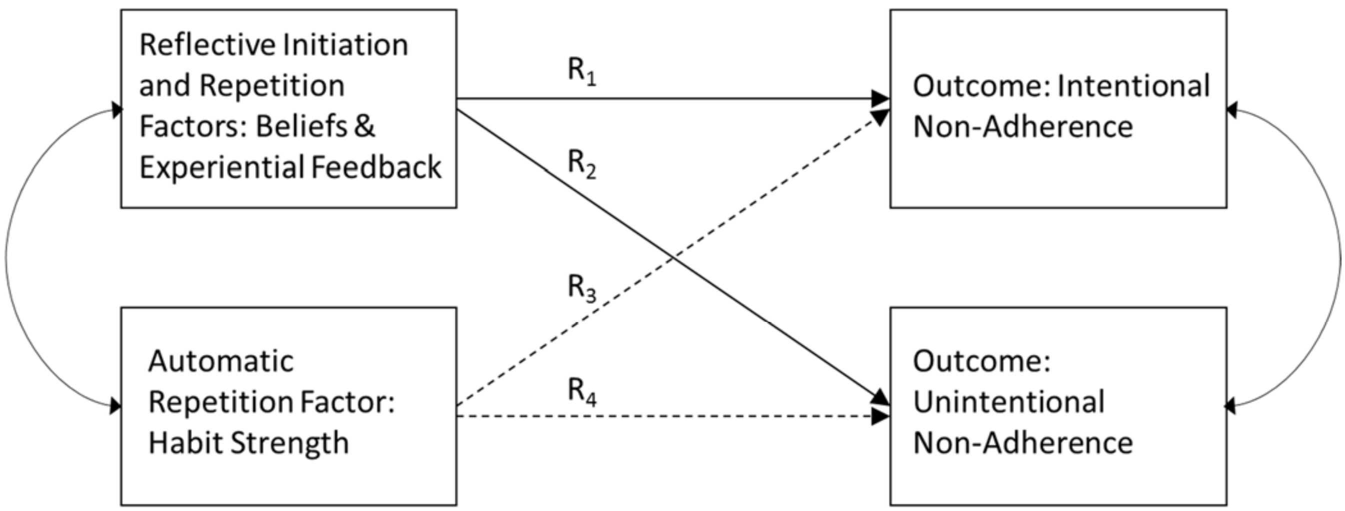


Figure 2

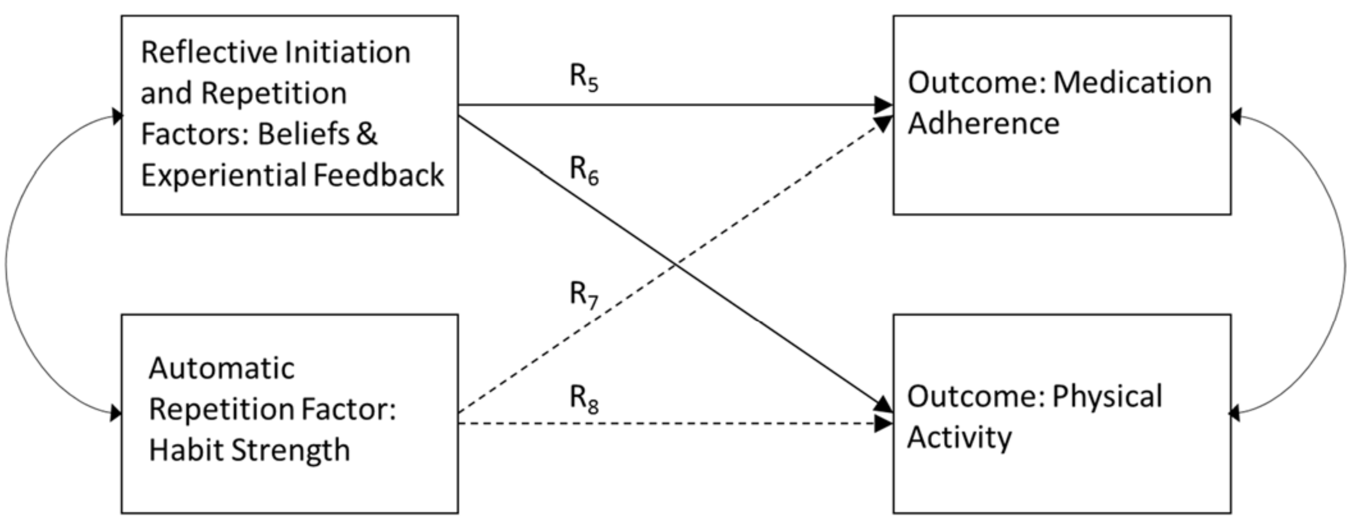
Figure 2 illustrates the theoretical hypotheses regarding the relative role of reflective and automatic behavioral repetition factors for determining different types of treatment-related adherence.

a.



Hypotheses 2b and 3b, respectively: $R_1 > R_2$ and $R_4 > R_3$

b.



Hypothesis 4: $R_7 - R_5 > R_8 - R_6$

Table 1

Demographic Information for Separate Samples.

	Washington DC In-Person Sample	Washington DC Online Sample	Milwaukee Wisconsin Sample (Online)
Sample Size	81	18	34
Female	64%	50%	61%
Hispanic Ethnicity	4%	0%	0%
Caucasian Race, Non-Hispanic	26%	31%	82%
African Race, Non-Hispanic	68%	56%	15%
Other or Multiple Racial Identity	6%	13%	3%
College Education/Equivalent or Higher Education	52%	50%	53%
Age	57.77 years (*SD* = 10.86)	54.72 years (*SD* = 14.72)	56.24 years (*SD* = 13.31)
% With Medication Prescription for ≥ 1 Year	87%	50%	62%
Modal Prescription Duration	1-3 years	6 months – 1 year	1-3 years
Average # Years Diagnosed with Type II Diabetes	10.42 years (*SD* = 8.39)	11.06 years (*SD* = 8.86)	9.47 years (*SD* = 21.04)

Table 2

Medication Adherence Variables: Descriptive statistics, bivariate correlations between variables, and internal consistency alphas (in italics).

		M(SD)	1	2	3	4	5	6	7	8	9
1.	Barriers to medication adherence (T1)	1.21 (.25)	*.61*								
2.	Medication-related necessity beliefs (T1)	3.48 (.78)	-.10	*.85*							
3.	Medication-related concerns (T1)	2.54 (.83)	.23**	-.11	*.82*						
4.	Medication-related experiential feedback (T1)	0 (.90)	-.06	.37**	-.25**	*.76*					
5.	Medication-taking habit strength (T1)	3.75 (.87)	-.21*	.14	-.12	.14	*.84*				
6.	Self-reported total medication adherence (MARS) (T2)	4.66 (.62)	-.37†	-.05	-.19*	.03	.40†	*.85*			
7.	Self-reported *intentional* non-adherence (T2)	1.24 (.60)	.38†	-.01	.15	.00	-.34†	-.95†	*.87*		
8.	Self-reported *unintentional* non-adherence (T2)	1.76 (1.00)	.28**	-.04	.19*	-.07	-.41†	-.77†	.54†	--	
9.	% Days adherent to medication (MEMS)	76.19 (24.3)	-.28*	-.06	-.17	.13	.37†	.53†	-.44†	-.50†	--
10.	% Doses taken on time (MEMS)	60.68 (32.0)	-.27*	-.12	-.25*	.20	.40†	.48†	-.44†	-.39†	.81†

Table 3

Physical Activity Variables: Descriptive statistics, bivariate correlations between variables, and internal consistency alphas (in italics).

		M(SD)	1	2	3	4	5	6
1.	Barriers to PA (T1)	2.30 (.72)	*.88*					
2.	PA-related necessity beliefs (T1)	3.62 (.77)	-.30†	*.81*				
3.	PA-related concerns (T1)	2.06 (.68)	.54†	-.29†	*.75*			
4.	PA-related experiential feedback (T1)	0 (.87)	-.24**	.36†	-.23**	*.66*		
5.	PA-related habit strength (T1)	2.54 (1.15)	-.40†	.37†	-.33†	.27**	*.95*	
6.	Self-reported PA frequency (T2)	3.07 (2.18)	-.38†	.31†	-.26**	.12	.47†	--
7.	Average daily steps (Fitbit)	4665.38 (3285.61)	-.08	.13	-.33**	.17	.32**	.38†

Table 4

Variables Predicting Self-Reported Total Medication Adherence (MARS) at Follow-Up (n=132; n=124 in the final column, with control variables).

	Model 1			Model 2			Model 3			Model 4			Model 4 with Control Variables		
Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	B	*B*	*SE B*	β	*B*	*SE B*	β
Barriers to medication adherence	-.61	.14	-.37†	-.55	.14	-.33†	-.55	.14	-.33†	-.45	.13	-.27**	-.39	.14	-.23**
Medication-related necessity beliefs				-.02	.04	-.03	-.01	.05	-.02	-.03	.04	-.05	-.03	.05	-.05
Medication-related concerns				-.09	.04	-.19*	-.10	.04	-.19*	-.09	.04	-.17*	-.04	.04	-.09
Medication-related experiential feedback							-.01	.04	-.03	-.03	.04	-.05	.01	.04	.01
Medication-taking habit strength										.15	.04	.32†	.15	.04	.32†
R^2-Change	.14			.03			.001			.09			.09		
F Change	20.35†			2.47			.10			15.69†			16.22†		

Note. *indicates regression coefficient is significantly different from 0 at *p*<0.05; **indicates *p*<0.01; †indicates *p*<0.001.

Table 5

Variables Predicting MEMS-Measured Percentage of Days Adherent to Prescribed Doses (n=80; n=74 in the final column, with control variables).

	Model 1			Model 2			Model 3			Model 4			Model 4 with Control Variables		
Variable	*B*	*SE B*	β	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	β	*B*	*SE B*	β
Barriers to medication adherence	-26.38	10.34	-.28*	-24.25	10.84	-.26*	-23.99	10.86	-.25*	-21.00	10.37	-.22*	-17.93	11.46	-.18
Medication-related necessity beliefs				-2.73	3.20	-.09	-3.40	3.29	-.12	-3.12	3.13	-.11	-2.06	3.69	-.06
Medication-related concerns				-2.96	3.15	-.11	-2.19	3.26	-.08	-.60	3.15	-.02	3.64	3.46	.13
Medication-related experiential feedback							3.31	3.67	.11	2.50	3.50	.08	4.89	3.79	.16
Medication-taking habit strength										8.81	2.94	.32**	8.57	3.06	.32**
R^2-Change	.08			.02			.01			.10			0.09		
F Change	6.51*			.71			.81			8.95**			7.83**		

Note. *indicates regression coefficient is significantly different from 0 at *p*<0.05; **indicates *p*<0.01; †indicates *p*<0.001.

Table 6

Variables Predicting Self-Reported PA Frequency at Follow-Up (n=133; n=126 in the final column, with control variables).

	Model 1			Model 2			Model 3			Model 4			Model 4 with Control Variables		
Variable	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	β
Barriers to PA (T1)	-1.14	.25	-.38†	-.87	.29	-.29**	-.88	.30	-.29**	-.62	.29	-.21*	-.54	.28	-.18*
PA-related necessity beliefs (T1)				.65	.24	.23**	.69	.25	.24**	.47	.25	.16	.52	.24	.18*
PA-related concerns (T1)				-.13	.31	-.04	-.14	.31	-.04	-.02	.29	-.01	.11	.30	.04
PA-related experiential feedback (T1)							-.12	.22	-.05	-.21	.21	-.09	-.30	.20	-.12
PA-related habit strength (T1)										.66	.17	.35†	.63	.16	.33†
R^2-Change		.14			.05			.002			.09			.08	
F Change		21.03†			3.97*			.29			15.74†			14.74†	

Note. *indicates regression coefficient is significantly different from 0 at $p<0.05$; **indicates $p<0.01$; †indicates $p<0.001$.

Table 7

Physical Activity-Related Variables Predicting Average Daily Steps, Measured By Accelerometer (n=76; n=74 with control variables included).

	Model 1			Model 2			Model 3			Model 4			Model 4 with Control Variables		
Variable	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	B	*B*	*SE B*	β	*B*	*SE B*	β
Barriers to PA (T1)	-353.8	527.5	-.08	847.5	620.7	.19	851.6	622.7	.19	1074.1	612.5	.24	1234.1	607.4	.27*
PA-related necessity beliefs (T1)				478.3	575.6	.10	452.5	578.4	.09	142.7	577.8	.03	46.73	567.0	.01
PA-related concerns (T1)				-1975.7	640.2	-.42**	-1859.7	685.5	-.39**	-1733.5	644.1	-.36**	-1643.8	645.4	-.35*
PA-related experiential feedback (T1)							372.7	498.5	.09	245.2	487.4	.06	245.0	477.0	.06
PA-related habit strength (T1)										759.3	331.2	.27*	672.8	329.7	.24*
R^2-Change	.01			.13			.01			.06			.05		
F Change	.45			5.32**			.56			5.26*			4.16*		

Note. *indicates regression coefficient is significantly different from 0 at $p<0.05$; **indicates $p<0.01$; †indicates $p<0.001$.