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Transtheoretical Model Constructs for Physical Activity Behavior are Invariant across Time among Ethnically Diverse Adults in Hawaii

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Abstract

Objectives—Physical activity (PA) research applying the Transtheoretical Model (TTM) to examine group differences and/or change over time requires preliminary evidence of factorial validity and invariance. The current study examined the factorial validity and longitudinal invariance of TTM constructs recently revised for PA.

Method—Participants from an ethnically diverse sample in Hawaii (N=700) completed questionnaires capturing each TTM construct.

Results—Factorial validity was confirmed for each construct using confirmatory factor analysis with full-information maximum likelihood. Longitudinal invariance was evidenced across a shorter (3-month) and longer (6-month) time period via nested model comparisons.

Conclusions—The questionnaires for each validated TTM construct are provided, and can now be generalized across similar subgroups and time points. Further validation of the provided measures is suggested in additional populations and across extended time points.

Keywords

factorial validity; longitudinal invariance; physical activity; ethnicity

Introduction

Given the numerous health benefits associated with regular physical activity (PA), national guidelines released by the United States Department of Health and Human Services (USDHHS, 2009) recommend adults engage in at least 150 minutes of moderate PA (or 75

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minutes of vigorous PA) each week. Unfortunately, 39% of adults are completely sedentary (Pleis & Lucas, 2009), worsening with age (Barnes, 2007). In order to address this public health concern and appropriately inform future interventions, further understanding of the determinants of PA behavior is necessary.

The Transtheoretical Model (TTM) has emerged as a framework to understand the initiation and adoption of regular PA (Marshall & Biddle, 2001). The TTM proposes temporal advancement through five distinct stages (Prochaska & Velicer, 1997) that correspond to additional constructs hypothesized to influence stage progression; which include, *barrier self-efficacy*, *temptation*, *decisional balance*, and *processes of change*. *Barrier self-efficacy* is the confidence to overcome barriers to being physically active, while *temptation* is characterized as the negative impulses to revert back to previous habits. *Decisional balance* represents the perceived pros and cons of adopting regular PA, and *processes of change* are the experiential and behavioral strategies for stage progression (Prochaska & Velicer, 1997).

The TTM was initially developed for application to smoking cessation; consequently, research applying TTM construct measures to PA behavior without critical preliminary examinations may produce biased results and/or inaccurate interpretations (Nigg, Geller, Motl, Horwath, Wertin, & Dishman, 2011). Given that successful PA promotion requires behavior adoption rather than cessation (i.e., smoking), the underlying mechanisms (i.e., TTM constructs) that motivate behavior change are also likely to vary. TTM constructs are widely used in PA research (Marshall & Biddle, 2001); however, tests to validate its application across time are severely limited (Nigg et al., 2011). The consequences of a measurement instrument that does not generalize to the targeted context are severely problematic. For instance, differences or changes detected across time may be a demonstration of shifts in measurement validity rather than true mean differences. The TTM continues to serve as a popular theoretical underpinning for PA research; hence, the preliminary support for its measurement properties is critical. The current investigation examined the measurement model for each TTM construct across time, representing the unobserved or latent factor(s) that operate as proxy for the representative set of measured variables (i.e., factor indicators).

A prior study examined the psychometric properties of each TTM construct, re-specifying each for PA behavior based on evidence of factorial validity (Paxton et al., 2008), or the degree to which a construct measure corresponds to its theoretical definition (Messick, 1995). Figure 1 illustrates the hypothesized TTM measurement models previously revised for PA behavior (Paxton et al., 2008). As shown in Figure 1a, barrier self-efficacy is theorized as a 1-factor construct with 6-indicators. Temptation (Figure 1b) is represented by two correlated latent factors, namely *affect* (3-indicators) and *competing demands* (4-indicators). As shown in Figure 1c, decisional balance is also indicated by two correlated latent factors, namely *pros* and *cons* with 5- and 4-indicators, respectively. Given unacceptable measurement properties of the original processes of change relative to PA, two revised models were hypothesized based on sequential exploratory factor analysis and expert recommendations. The first, depicted in Figure 1d, includes two higher order, correlated latent factors (i.e., experiential and behavioral) that represent eight of the original 10 processes and 18-indicators (Paxton et al., 2008). An additional hypothesized model removed two processes found irrelevant to PA and merged four others, resulting in a 5-factor measurement model with 21-indicators (R.K. Dishman, personal communication, September 15, 2006).

In addition to factorial validity, the revised measurement models demonstrated acceptable population invariance across age, gender, and diverse ethnic subgroups (Paxton et al., 2008). Such evidence implies that each TTM construct is measured similarly across these

subgroups; hence, detection of between group variability can be justified as true differences rather than shifts in measurement properties (King-Kallimanis, Oort & Garst, 2010; Vandenberg & Lance, 2000). Although population invariance sanctions accurate mean comparisons between groups, such evidence is only relevant within cross-sectional data. Given the TTM has served as the theoretical underpinning for numerous longitudinal PA examinations and intervention evaluations, preliminary evidence of factorial invariance over time is necessary. In general, the test of longitudinal invariance determines whether the measurement model of a construct is measured consistently across time, which is a fundamental aspect of evaluating temporal change in latent factors (Brown, 2006; MacKinnon, Fairchild, & Fritz, 2007). In spite of its necessity, tests of longitudinal invariance for TTM constructs are currently deficient in the PA context (Nigg, et al., 2010).

The current study had two primary aims: first, to confirm the factorial validity of the TTM measurement models recently revised for PA behavior (Paxton et al., 2008), and second, to determine the degree of longitudinal invariance of each. Based on previous reports, appropriate factorial validity was hypothesized for each TTM construct at baseline, 3-months, and 6-months. Subsequently, consecutive hypotheses tested four levels of longitudinal invariance for each TTM construct: (1) the same conceptual framework was measured at each time point (configural invariance), (2) the loadings of corresponding factor indicators are similar from baseline to 3-months and baseline to 6-months (weak invariance), (3) maintaining weak invariance, the intercepts of corresponding factor indicators are similar from baseline to 3- and 6-months (strong invariance), and (4) the error variance of factor indicators do not change from baseline to 3- and 6-months (strict invariance). Current study outcomes provide valid measurement models for future PA examinations, insuring accurate application across similar time periods.

Methods

Participants and Procedure

A population-based sample of adult participants ($n=700$; mean age=47.9 years, standard deviation (SD)=17.1) living in Hawaii were 63% female; 32% Asian, 22% Native Hawaiian/Pacific Islander, 38% Caucasian, and 8% other. The average years of education was 14.6 (SD=2.8) with a median income ranging from \$40,000 to \$50,000 (SD=\$28,000). Following informed consent, participants were recruited via random digit dialing to complete a 30-minute phone interview with trained interviewers. Monetary incentives (\$10–\$25) were given for each completed survey. All procedures were approved by the University Human Subjects Committee.

Questionnaire items were programmed into a computer assisted telephone interview (CATI) system and then piloted for interpretability and ease of administration. Interviewers attended a 2-day training session, and experienced university personnel performed evaluations at each time point. Based on a scale ranging from 1 (very poor) to 5 (excellent), interviewers were evaluated high on their adherence to protocol (mean (M) =4.4, SD=0.3), politeness (M=4.1, SD=0.8), articulation (M=4.7, SD=0.4), and professionalism (M=4.7, SD=0.4).

Measures

Barrier Self-Efficacy—Participants rated 6-items on a 5-point scale (1=not at all confident to 5=completely confident), corresponding to six unique PA domains: negative affect, excuse making, being active alone, equipment access, resistance from others, and weather (Benisovich, Rossi, Norman, & Nigg, 1998; Marcus, Selby, Niaura, & Ross, 1992). The barrier self-efficacy measurement model demonstrated high internal consistency ($\alpha=0.85$) and invariance across gender, age, and ethnic subgroups (Paxton, et al., 2008).

Temptation—A previous temptation scale (Hausenblas et al., 2001) was revised for PA behavior, capturing *affect* and *temptation* with 3- and 4-items, respectively. Participants reported their temptation to not engage in PA during various situations on a scale ranging from 0% (not at all tempted) to 100% (extremely tempted). High internal consistency was reported for affect (0.87) and competing demands (0.91), and the measurement model for temptation was found invariant across gender, age, and ethnic subgroups (Paxton, et al., 2008).

Decisional Balance—The decisional balance scale developed for PA behavior (Nigg, Rossi, Norman, & Benisovich, 1998) was recently revised, including 5-items for *pros* and 4-items for *cons*. Participants responded on a scale ranging from 1 (not important) to 5 (extremely important). High internal consistency was reported for pros (0.83) and cons (0.71), and the decisional balance measurement model was invariant across gender and ethnic subgroups (Paxton, et al., 2008).

Processes of Change—The processes of change scale for PA asked participants to report how frequent (1=never to 5=repeatedly) they applied each process during behavior change attempts (Nigg et al., 1998). Based on prior evidence of factorial validity, two separate processes of change measurement models were hypothesized. The first is a higher order, 2-factor model with 18-items, which demonstrated internal consistency ranging from 0.67 to 0.72 for experiential processes and 0.78 to 0.80 for behavioral. The second is a 5-factor model (21-items) with internal consistency ranging from 0.72 to 0.88. Both revised models demonstrated invariance across gender, age, and ethnic subgroups (Paxton, et al., 2008).

Data Analysis

Revised TTM measurement models for PA were examined for factorial validity and longitudinal invariance across 3- and 6-months. Confirmatory factor analysis (CFA) and nested model comparisons were performed using full-information maximum likelihood (FIML) estimation in AMOS Version 17.0 (Arbuckle, 2008). Missing responses to questionnaire items in the current analysis ranged from 1% to 4% for each TTM factor. FIML estimation is generally regarded as the optimal method for handling missing data (Allison, 2003; Enders, 2001), demonstrating accurate fit indices and parameter estimates in simulated analyses with up to 25% missing responses (Arbuckle, 1996; Enders & Bandalos, 2001).

Model Fit

Model fit statistics were used to evaluate factorial validity, reflecting the extent to which estimates of the hypothesized model reproduced the observed variances and covariances. The chi-square (χ^2) statistic assessed the exact fit of the specified model matrix (S) to the observed variance/covariance matrix (Σ); however, χ^2 is based on a stringent hypothesis ($S=\Sigma$) with sensitivity to sample size (Bollen, 1989; Joreskog, 1993). Accordingly, additional indices aided in model fit evaluations. The root mean square error of approximation (RMSEA) index adjusts for model parsimony, suggesting adequate fit at values close or below 0.08. The “close” fit (CFit) statistic is a statistical test of closeness of model fit using RMSEA, which is operationalized as RMSEA values ≤ 0.05 and supported by a non-significant CFit statistic ($p > 0.05$) (Browne & Cudeck, 1993). The comparative fit index (CFI; Bentler, 1990) and the non-normed Tucker-Lewis index (TLI; Tucker & Lewis, 1973) evaluated model adequacy in relation to a more restricted (null) model, demonstrating acceptable and good fit values at 0.90 and 0.95, respectively (Bentler, 1990; Hu & Bentler,

1999). Estimates of factor loadings, intercepts, variances, residual variances, and z-scores (>1.96) were also inspected for sign and magnitude.

Longitudinal Factorial Invariance

Longitudinal invariance was examined by fitting and comparing a sequence of nested CFA models. Analyses began with an unconstrained or configural model and progressed towards more restricted (nested) models to evaluate the tenability of each sequentially placed constraint (Little, 1997; Widaman & Reise, 1997). The configural model tested whether the pattern of indicator-to-factor relationships were parallel at each time point, functioning as a prerequisite (baseline model) for additional invariance tests (Horn & McArdle, 1992). Weak invariance was tested first by constraining corresponding factor loadings equal across time points (Horn & McArdle, 1992; Widaman & Reise, 1997). The subsequent model examined strong invariance by maintaining weak invariance with additional equality constraints placed on the intercepts of corresponding indicators across time (Meredith, 1993). Evidence of strong invariance ensures that differences detected in indicator scores are adequately captured as temporal change in the hypothesized latent factor mean (Little, Preacher, Card, & Selig, 2007); hence, providing the minimal evidence necessary to establish TTM measurement models longitudinally invariant. The final model maintained strong invariance and tested the strict invariance hypothesis by constraining the residual variance of like indicators to be equal across time (Meredith, 1993; Widaman & Reise, 1997). Finally, the stability of each TTM latent factor across time was examined as the correlation coefficients of latent factor scores from baseline to 3- and 6-months, which is interpreted as the stability of ranks across time on the latent variables.

Evaluating Nested Model Change

Longitudinal invariance was justified at each level of model constraint by a non-significant χ^2 change (Δ) relative to degrees of freedom (df) Δ (Bollen, 1989) and minimal CFI Δ ($CFI_{\text{constrained model}} - CFI_{\text{unconstrained model}} = 0.01$) (Cheung & Rensvold, 2002). Parallel to biases associated with the χ^2 statistic, $\chi^2\Delta$ is also susceptible to sample size and model complexity and may reject null hypotheses when only trivial model differences exist (Wu, Li, & Zumbo, 2007). Based on simulation research, Cheung & Rensvold (2002) determined CFI $\Delta = 0.01$ superior to $\chi^2\Delta$ when empirically evaluating nested model comparisons. Although further validation is warranted, their recommendations have been deemed the most justifiable to date (Wu, Li, & Zumbo, 2007); consequently, the current study emphasized CFI Δ as the final determinant of longitudinal invariance.

Results

Table 1 provides the M and SD for each TTM latent factor. As seen, participants' barrier self-efficacy construct was slightly above average. Participants had a stronger percentage scale for competing demands (44%) compared to positive affect (38%), but demonstrated higher pros than cons. The overall process of change construct was reflected similarly in both hypothesized models; and, the experiential and behavioral processes of change within the higher order, 2-factor model were also similar in value. Results of factorial validity for TTM construct models are provided at each time point in the following sections. Tables 2 and 3 present the fit indices for each level of invariance test, including $\chi^2\Delta$ and CFI Δ .

Barrier Self-Efficacy

The hypothesized barrier self-efficacy model demonstrated good factorial validity at baseline ($\chi^2 = 68.88$, $df = 9$, CFI = 0.95, RMSEA = 0.12, TLI = 0.86), 3-months ($\chi^2 = 71.49$, $df = 9$, CFI = 0.95, RMSEA = 0.10, TLI = 0.90), and 6-months ($\chi^2 = 119.90$, $df = 9$, CFI = 0.91, RMSEA = 0.13, TLI = 0.78). As illustrated in Table 2, the configural model

provided a good fit to the data at each time point, and the hypothesis of strict invariance was sustained across 3- and 6-months (i.e., $CFIA < 0.01$). Barrier self-efficacy latent factor correlations from baseline to 3- and 6-months were 0.69 and 0.69, respectively; which is an indication of high temporal stability.

Temptation

The hypothesized 2-factor measurement model for temptation demonstrated appropriate factorial validity at baseline ($\chi^2 = 76.26$, $df = 13$, CFI = 0.97, RMSEA = 0.08, TLI = 0.96), 3-months ($\chi^2 = 42.32$, $df = 13$, CFI = 0.99, RMSEA = 0.06, TLI = 0.98), and 6-months ($\chi^2 = 48.94$, $df = 13$, CFI = 0.99, RMSEA = 0.06, TLI = 0.97). Given minimal CFIA, the hypothesis of strict factorial invariance was upheld (Table 2). Stability coefficients across 3- and 6-months were 0.17 and 0.15 for affect and 0.13 and 0.13 for competing demands, respectively.

Decisional Balance

The hypothesized 2-factor decisional balance model revealed good factorial validity at baseline ($\chi^2 = 69.02$, $df = 26$, CFI = 0.97, RMSEA = 0.05, TLI = 0.96), 3-months ($\chi^2 = 67.89$, $df = 26$, CFI = 0.98, RMSEA = 0.05, TLI = 0.96), and 6-months ($\chi^2 = 66.16$, $df = 26$, CFI = 0.97, RMSEA = 0.05, TLI = 0.95). The hypothesis for strict invariance was confirmed across both time points (i.e., $CFIA < 0.01$; see Table 2), and the stability coefficients across 3- and 6-months were 0.58 and 0.67 for pros and 0.58 and 0.48 for cons, respectively.

Processes of Change

The hypothesized 2-factor, higher order measurement model revealed adequate factorial validity at baseline ($\chi^2 = 382.91$, $df = 126$, CFI = 0.94, RMSEA = 0.05, TLI = 0.92), 3-months ($\chi^2 = 432.97$, $df = 126$, CFI = 0.92, RMSEA = 0.06, TLI = 0.90), and 6-months ($\chi^2 = 319.83$, $df = 126$, CFI = 0.95, RMSEA = 0.05, TLI = 0.93). The strict invariance hypothesis was sustained across time points (i.e., $CFIA < 0.01$; see Table 3), and the stability coefficients across 3- and 6-months were 0.72 and 0.69 for behavioral processes and 0.75 and 0.75 for experiential, respectively.

The hypothesized 5-factor measurement model revealed adequate factorial validity at baseline ($\chi^2 = 579.95$, $df = 179$, CFI = 0.93, RMSEA = 0.06, TLI = 0.91), 3-months ($\chi^2 = 569.87$, $df = 179$, CFI = 0.93, RMSEA = 0.06, TLI = 0.91), and 6-months ($\chi^2 = 538.52$, $df = 179$, CFI = 0.94, RMSEA = 0.05, TLI = 0.92). The strict invariance hypothesis was sustained across time points (i.e., $CFIA < 0.01$; see Table 3), and the stability coefficients for the five factors across 3- and 6-months ranged from 0.57 to 0.79 and 0.62 to 0.72, respectively.

Discussion

The first study aim was to evaluate the structural properties of each TTM measurement model relevant to PA behavior. Results confirmed the factorial validity of each TTM construct, supporting previous research (Paxton et al., 2008). This suggests that each indicator was significantly relevant to the hypothesized latent factor, and absent of any disproportional influences on the aggregated indicator scores. Given that the variance in each indicator score is significantly explained by the related construct, data derived by these measures are consistent with theoretical expectations and can be reported with accuracy. Results of the second aim, which was to test the longitudinal invariance of each TTM measurement model, are discussed in the following sections.

Configural Invariance

CFA results provide evidence of configural invariance for TTM measurement models at each time point, supporting the hypothesis that the theoretical framework of each is being measured the same over time. Given this, measurement models and scales are assumed theoretically sound within the PA context, capturing each TTM construct as theoretically intended.

Longitudinal Factorial Invariance

The weak invariance hypothesis was supported for each TTM measurement model, suggesting invariant factor loadings across time (i.e., equal units of measure for each of the underlying factors). The expectation of strong invariance was also upheld for all models, implying invariant indicator intercepts across time points. Indicator intercepts reflect the predicted value of factor indicators when the latent factor score is zero (Brown, 2006). Finally, the expectation of strict invariance was also upheld for all models, implying equal residual variances among like indicators across time. Support for strict invariance collectively signifies parallel theoretical constructs that are measured on the same scale and with the same level of precision across time points, which implies measurement invariance (Brown, 2006; Knight, Roosa, Umana-Taylor, 2009; Little et al., 2007). Consequently, evidence of longitudinal invariance assures that differences detected over shorter (3-months) and longer (6-months) time periods can be attributed to true change in the TTM construct rather than measurement artifact.

Stability Coefficients

Stability coefficients represent TTM latent factor correlations across time, indicating the degree to which the relative ordering of participants on each latent factor remained similar across time (Pitts, West, & Tein, 1996). Moderately high to high stability coefficients indicated that, relevant to their PA behavior, participants' *barrier self-efficacy*, *decisional balance*, and *processes of change* remained stable over time. Conversely, the low stability coefficients of the *temptation* latent factors imply fluctuations in participants' *affect* (e.g., anger, satisfaction, stress) and *competing demands* (e.g., family, work) across 3- and 6-months. Theoretically, trait-like characteristics (e.g., ability, confidence) are expected to remain fairly stable over time, whereas others such as mood (*affect*) or condition (*competing demands*) are state-like and will likely vary over time (Nesselroade, 1990; Pitts, West, & Tein, 1996). Therefore, the low stability of decisional balance is expected, and interpreted as natural fluctuations in the participants' disposition.

Conclusions

TTM constructs are widely used in cross-sectional and longitudinal PA research (Marshall & Biddle, 2001; Nigg et al., 2010); however, lack of factorial invariance introduces the risk of measurement bias between groups and across time. The current study extended previous evidence of population invariance, providing structurally sound TTM measurement models that are also invariant across 3- and 6-month time periods. Given that both hypothesized process of change models were structurally sound and invariant, no evidence-based recommendation can be made. Both processes of change models were theoretically driven and developed based on empirical evidence, which provides a strong evidence-based foundation for further examination. Practically speaking, researchers are encouraged to utilize the original process of change questionnaire (Nigg et al., 1998) during data collection and consider the currently reported models throughout measurement validation and data analysis/interpretation.

The questionnaires corresponding to each TTM measurement model are provided in Appendices A–C. Future PA research can now apply the reported TTM constructs uniformly to similar subgroups and time points, and any differences detected can be interpreted as true differences rather than shifts in measurement validity. With valid measurement models in place, future research can begin to employ more advanced statistical analyses of the TTM in its entirety (e.g., multivariate latent growth modeling, structural equation modeling) to examine moderating and mediating relationships relative to changes in PA and/or evaluate intervention effectiveness.

There are a few noteworthy limitations of the current study. First, the participant sample was drawn from a highly ethnically diverse population living in Hawaii that may not generalize to other US populations; alternatively, invariance across a uniquely diverse population may indicate stronger validity. Similar tests in various populations are necessary, such as varying age groups to further extend assurance of accurate measurement (e.g., adolescents, older adults, etc). Second, although longitudinal invariance was examined across multiple time points, many PA interventions exceed these time frames (e.g., 12-months, 24-months); thus, evaluations across longer time periods are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- In this study we test the measurement properties of the Transtheoretical Model in the physical activity context
- In this study we confirm appropriate factorial validity for each Transtheoretical Model construct via confirmatory factor analysis
- This study found the Transtheoretical constructs to be invariant across a shorter (3-month) and longer (6-month) time period
- The questionnaires for each validated Transtheoretical Model construct are provided, and can now be generalized across time points
- Further validation of the provided measures is suggested in additional populations and across extended time points

Figure 1.

Individual hypothesized measurement models for : (a) *Barrier Self-efficacy* with 6 indicators; (b) *Temptation* represented by an affect factor [A] with 3 indicators and competing demands factor [CD] with 4 indicators; (c) decisional balance was represented by a pro factor [P] with 5 indicators and a con factor [C] with 4 indicators; (d) a higher-order, 2-factor model for *Process of Change* with an experiential factor derived from 4 first order factors with 2 indicators each [consciousness raising (CR), dramatic relief (DR), environmental re-evaluation (ER), social liberation (SO)], and a behavioral factor also derived from 4 factors with 2 indicators each [reinforcement management and self-liberation (RMSL), counter conditioning (CC), helping relationships (HR), and stimulus control (SC)]; and (e) a 5-factor model for *Process of Change* that includes a SRF factor [7 indicators from self-revaluation, reinforcement management, and self liberation processes], a DE factor [5 indicators from dramatic relief and environmental revaluation processes], and 3 additional factors with 3 indicators each [counter conditioning (CC), helping relationships (HR), and consciousness raising (CR)] and include three-items each. See Appendix A–C for included items.

Table 1

Means and standard deviations for all transtheoretical latent factors at baseline

Hypothesized Measurement Models & Factors		Indicators	Scale	Mean	SD
Barrier Self-Efficacy		SE1-SE6	1-5	3.16	1.00
Temptation	Affect	A1-A3		37.63	27.00
	Competing Demands	CD1-CD4	0-100	43.65	28.96
	Temptation			41.11	24.58
Decisional Balance	Pros	P1-P5		4.08	0.88
	Cons	C1-C4	1-5	1.70	0.81
	Decisional Balance			2.38	1.13
Process of Change	Consciousness Raising	CR1-CR2		2.52	1.16
	Dramatic Relief	DR1-DR2		2.51	1.10
	Environmental Reevaluation	ER1-ER2		3.60	1.14
	Social Liberation	SO1-SO3		3.67	0.94
	Experiential Processes			3.07	0.76
	Counter Conditioning	CC1-CC2	1-5	2.90	1.16
	Helping Relationships	HR1-HR2		2.46	1.19
	Reinforcement Management, Self-Liberation	RMSL1-RMSL4		3.83	0.94
	Stimulus Control	SC1-SC2		2.96	1.42
	Behavioral Processes			3.20	0.84
Higher Order, 2-Factor				3.14	0.73
Self-Reevaluation, Reinforcement Management, Self-Liberation		SRF1-SRF7		3.99	0.88
Dramatic Relief, Environmental Reevaluation		DE1-DE5		3.05	0.95
Counter Conditioning		CC1-CC3	1-5	3.00	1.06
Helping Relationships		HR1-HR3		2.56	1.15
Consciousness Raising		CR1-CR3		2.50	1.05
5-Factor				3.21	0.73

Note: SD=standard deviation

Longitudinal invariance for barrier self-efficacy, temptation, and decisional balance measurement models across 3- and 6-months

Table 2

Barrier Self-Efficacy	χ^2 (df)	$\chi^2 \Delta$ (df Δ)	CFI	CFIA	RMSEA	CFit	TLI
Configural	203.13 (47)		0.95		0.07	.001	0.92
Weak	205.48 (52)	2.35 (5)	0.95	0.00	0.07	.001	0.93
Strong	205.92 (53)	0.44 (1)	0.95	0.00	0.06	.005	0.93
Strict	236.67 (59)	30.75 (6)*	0.95	0.00	0.07	.001	0.93
3-month							
Configural	253.98 (47)		0.93		0.08	.001	0.90
Weak	262.12 (52)	8.14 (5)	0.93	0.00	0.08	.001	0.90
Strong	263.18 (53)	1.06 (1)	0.93	0.00	0.08	.001	0.90
Strict	272.28 (59)	9.10 (6)	0.93	0.00	0.07	.001	0.90
6-month							
Configural	253.98 (47)		0.93		0.08	.001	0.90
Weak	262.12 (52)	8.14 (5)	0.93	0.00	0.08	.001	0.90
Strong	263.18 (53)	1.06 (1)	0.93	0.00	0.08	.001	0.90
Strict	272.28 (59)	9.10 (6)	0.93	0.00	0.07	.001	0.90
Temptation							
Configural	174.26 (66)		0.98		0.05	0.60	0.97
Weak	177.28 (71)	3.02 (6)	0.98	0.00	0.05	0.75	0.97
Strong	187.37 (74)	10.09 (3)	0.98	0.00	0.05	0.72	0.97
Strict	208.84 (81)	21.47 (7)*	0.98	0.00	0.05	0.69	0.97
3-month							
Configural	177.27 (66)				0.05	0.55	0.97
Weak	180.56 (71)	3.29 (6)	0.98	0.00	0.05	0.71	0.97
Strong	183.95 (74)	3.03 (3)	0.98	0.00	0.05	0.77	0.97
Strict	222.29 (81)	38.34 (7)*	0.97	0.01	0.05	0.49	0.97
6-month							
Configural	177.27 (66)				0.05	0.55	0.97
Weak	180.56 (71)	3.29 (6)	0.98	0.00	0.05	0.71	0.97
Strong	183.95 (74)	3.03 (3)	0.98	0.00	0.05	0.77	0.97
Strict	222.29 (81)	38.34 (7)*	0.97	0.01	0.05	0.49	0.97
Decisional Balance							
Configural	256.51 (122)		0.97		0.04	0.99	0.95
Weak	269.28 (129)	12.77 (7)	0.97	0.00	0.04	0.99	0.95
Strong	279.35 (132)	10.07 (3)	0.96	0.01	0.04	0.99	0.95
Strict	325.90 (141)	46.55 (9)*	0.95	0.01	0.04	0.96	0.95
3-month							
Configural	256.51 (122)		0.97		0.04	0.99	0.95
Weak	269.28 (129)	12.77 (7)	0.97	0.00	0.04	0.99	0.95
Strong	279.35 (132)	10.07 (3)	0.96	0.01	0.04	0.99	0.95
Strict	325.90 (141)	46.55 (9)*	0.95	0.01	0.04	0.96	0.95
6-month							
Configural	203.84 (122)		0.98		0.03	1.00	0.97
Weak	208.35 (129)	4.51 (7)	0.98	0.00	0.03	1.00	0.97

Barrier Self-Efficacy	χ^2 (df)	$\chi^2 \Delta$ (df Δ)	CFI	CFIA	RMSEA	CFit	TLI
Strong	214.09 (132)	5.74 (3)	0.98	0.00	0.03	1.00	0.97
Strict	255.85 (141)	41.76 (9)*	0.97	0.01	0.03	1.00	0.96

Note:

* $p < 0.001$; χ^2 =chi-square; df=degrees of freedom; Δ =change; CFI=comparative fit index; RMSEA = root mean square error of approximation; CFit = test of close fit (probability RMSEA .05); SRMR = standardized root mean square residual; TLI = Tucker-Lewis Index

Table 3
Longitudinal invariance for two process of change measurement models across 3- and 6-months

Higher Order, 2-Factor	χ^2 (df)	$\chi^2 \Delta$ (df Δ)	CFI	CFIA	RMSEA	CFit	TLI
Configural	1149.37 (546)		0.94		0.04	1.00	0.92
1 st order Weak	1158.93 (556)	9.56 (10)	0.94	0.00	0.04	1.00	0.92
2 nd order Weak	1175.36 (562)	16.43 (6)	0.94	0.00	0.04	1.00	0.92
1 st order Strong	1193.26 (570)	17.90 (8)	0.94	0.00	0.04	1.00	0.92
2 nd order Strong	1197.63 (573)	4.37 (3)	0.93	0.01	0.04	1.00	0.92
Strict	1329.38 (591)	131.75 (18)*	0.92	0.01	0.04	1.00	0.91
Configural	1000.59 (546)		0.95		0.04	1.00	0.94
1 st order Weak	1015.27 (556)	14.68 (10)	0.95	0.00	0.03	1.00	0.94
2 nd order Weak	1034.95 (562)	19.68 (6)	0.95	0.00	0.04	1.00	0.94
1 st order Strong	1045.49 (570)	10.54 (8)	0.95	0.00	0.04	1.00	0.94
2 nd order Strong	1053.39 (573)	7.90 (3)	0.95	0.00	0.04	1.00	0.94
Strict	1146.58 (591)	93.19 (18)*	0.94	0.01	0.04	1.00	0.93
5-Factor	χ^2 (df)	$\chi^2 \Delta$ (df Δ)	CFI	CFIA	RMSEA	CFit	TLI
Configural	1675.09 (753)		0.93		0.04	1.00	0.92
Weak	1689.02 (769)	13.93 (16)	0.93	0.00	0.04	1.00	0.92
Strong	1716.25 (784)	27.23 (15)	0.93	0.00	0.04	1.00	0.92
Strict	1913.82 (805)	197.57 (21)*	0.92	0.01	0.04	1.00	0.91
Configural	1566.47 (753)		0.94		0.04	1.00	0.93
Weak	1587.82 (769)	21.35 (16)	0.94	0.00	0.04	1.00	0.93
Strong	1621.32 (784)	33.50 (15)	0.94	0.00	0.04	1.00	0.93
Strict	1792.60 (805)	171.28 (21)*	0.93	0.01	0.04	1.00	0.92

Note:

* $p < 0.001$; χ^2 = chi-square; df = degrees of freedom; Δ = change; CFI = comparative fit index; RMSEA = root mean square error of approximation; CFit = test of close fit (probability RMSEA ≤ 0.05); SRMR = standardized root mean square residual; TLI = Tucker-Lewis Index