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INVESTIGATING AND COMPARING THE MECHANISMS OF BEHAVIOR
CHANGE TO PREVENT SMOKING ACQUISITION IN MIDDLE SCHOOL
STUDENTS

BY

ALLIE WESLEY SCOTT

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

PSYCHOLOGY

UNIVERSITY OF RHODE ISLAND

2017

DOCTOR OF PHILOSOPHY
OF
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2017

ABSTRACT

The disease consequences of smoking such as high blood pressure, heart disease, and lung cancer, are well documented (U.S. Department of Health and Human Services, 1964, 1989, and 2010). One clear finding from epidemiological studies is that the early uptake of smoking during adolescence can lead to addiction in adulthood. A recent study by the Centers for Disease Control (CDC) found nearly 9 out of 10 adult cigarette smokers tried their first cigarette as minors and 99% tried smoking by age 26 (CDC, 2017). To mitigate smoking incidence and reduce the harm caused by smoking, a number of primary prevention programs have targeted adolescents during the early middle school and high school years. It is well established in the literature that the causes of smoking are numerous and involve the complex interplay of many factors. The Transtheoretical Model (TTM) is a model of health behavior change capable of investigating and comparing many factors of smoking acquisition. The purpose of this study was to investigate the causal effects of TTM processes of change and mediators of smoking prevention on smoking acquisition during adolescence. The secondary data comes from a longitudinal sample of nonsmoking middle school students (N=1573) followed over 4 years. We found TTM process measures (Dramatic Relief, Self-Liberation, and Stimulus Control) in the 6th grade led to small indirect effects through situational temptations in the 7th -8th grades on smoking acquisition by 9th grade. There was no evidence that gender or race moderated the indirect effects in the final models. This was the first study to determine causal relationships between TTM factors and smoking uptake. Future studies may consider investigating the applicability of the models in more diverse groups.

ACKNOWLEDGMENTS

I would like to take this opportunity to acknowledge my major professor, Dr. Wayne Velicer for all of his time, effort, feedback, and patience over the past few years. His knowledge and encouragement has provided the foundation for my growth as a researcher. I would also like to thank Dr. Colleen Redding and Dr. Lisa Harlow for their participation as my core committee and sharing their experienced ideas and evaluations to improve this project. Further, Dr. Mary Sullivan has provided complementary advice and support that has helped me make great contributions to the field. I'd also like to acknowledge my parents, close family members and friends for their plethora of support, both tangible and emotional, over the past seven years of my graduate life. Lastly, I would like to thank my dear friend Russo who brought joy into my life when I needed it. I miss you and I pray that you're resting in peace buddy.

PREFACE

This dissertation is comprised of four interrelated manuscripts that represent an investigation of the Transtheoretical mechanisms of smoking acquisition in middle-school aged adolescents followed over 4 years. Implications and future directions for research are discussed. All of the pages have been formatted in the accepted font and margin requirements. Tables and figures are prefixed with the manuscript number for clarity of labeling across the dissertation. Manuscript format is in use.

TABLE OF CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGMENTS.....	iii
PREFACE.....	iv
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
Statement of the Problem.....	1
Chapter 1: Overview of Studies.....	3
The Transtheoretical Model	3
Smoking Prevention Measures.....	5
Other Stage Models.....	6
Overview of Mediation Analysis.....	9
Mediation and Substance Use Prevention.....	11
Project Best.....	12
Purpose of this study.....	13
Research Aims.....	14
References.....	16
Chapter 2: Investigating the Mechanisms Of Smoking Acquisition In Adolescents:	
Statistical Mediation With Single Mediators.....	23
Abstract.....	24
Introduction.....	26
Method.....	33

Results.....	39
Discussion.....	43
References.....	51
 Chapter 3: Testing For Moderation In Longitudinal Mediation Models Of Smoking	
Acquisition: Factorial Invariance Across Subgroups.....	71
Abstract.....	72
Introduction.....	74
Method.....	82
Results.....	91
Discussion.....	96
References.....	102
Chapter 4: CONCLUSIONS FROM STUDIES.....	123
APPENDIX A. Study Measures.....	126
APPENDIX B. Single Mediator Path Models with Standardized Estimates.....	128
Bibliography.....	160

LIST OF TABLES

TABLE	PAGE
Table 2.1. Independent samples t-test results for all TTM variables between males and females at baseline	61
Table 2.2. Study variables means and standard deviations at baseline and over time.	62
Table 2.3. Single mediator model fit statistics with Pros, Cons and Temptations as Mediators	63
Table 2.4. Unstandardized (With Standard Errors) longitudinal regression paths describing the mediation pathway; Processes Of Change At time 1 and time 2 to mediator at time 2 (a_1) and time 3 (a_3); the mediator at time 2 to smoking outcome at time 3 (b_3) and mediator at time 3 to smoking outcome at time 4 (b_5)	64
Table 2.5. Unstandardized and standardized products, standard errors, and 90% Confidence Intervals for the processes of change that demonstrated statistical significance	66
Table 3.1. Independent samples t-test results for males and females at baseline	111
Table 3.2. Model Fit statistics and nested model comparisons.....	112

LIST OF FIGURES

FIGURE	PAGE
Figure 2.1 Path Diagram Of Autoregressive Single Mediator Model II.....	67
Figure 2.2 Autoregressive Model II: Dramatic Relief With Situational Temptations As The Mediator.....	68
Figure 2.3 Autoregressive Model II: Self Liberation With Situational Temptations As The Mediator.....	69
Figure 2.4 Autoregressive Model II: Stimulus Control With Situational Temptations As The Mediator.	70
Figure 3.1 Path Diagram Of Autoregressive Single Mediator Model II.....	114
Figure 3.2 Factorial Invariance Of Dramatic Relief With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Males	115
Figure 3.3 Factorial Invariance Of Dramatic Relief With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Females.	116
Figure 3.4 Factorial Invariance Of Dramatic Relief With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Whites.	117
Figure 3.5 Factorial Invariance Of Dramatic Relief With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Non-Whites.	118
Figure 3.6 Factorial Invariance Of Stimulus Control With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Males.....	119
Figure 3.7 Factorial Invariance Of Stimulus Control With Situational Temptations As The Mediator: Path Diagram Of Autoregressive Model II For Females.	120

Figure 3.8 Factorial Invariance Of Stimulus Control With Situational Temptations As
The Mediator: Path Diagram Of Autoregressive Model II For Whites. 121

Figure 3.9 Factorial Invariance Of Stimulus Control With Situational Temptations As
The Mediator: Path Diagram Of Autoregressive Model II For Non-Whites. 122

Statement of the Problem

Much research has explored the complex etiology of smoking. It is well established in the literature that the causes and correlates of smoking acquisition involve the complex interaction of many personal, socio-ecological, and psychological factors (Flay et al., 2005; Hwang et al., 2004; Leventhal and Cleary, 1980). One clear finding is that adolescence is an important phase of development for preventing the uptake of smoking and other forms of tobacco use. Studies have shown nearly 9 out of 10 adult cigarette smokers tried their first cigarette during adolescence and 99% tried smoking by age 26 (CDC, 2017).

Given that the uptake of smoking during adolescence is influenced by a plethora of interrelated factors, identifying and comparing some of the potential causal pathways involved in smoking acquisition presents a challenge for models of smoking acquisition. The Transtheoretical Model (TTM) is a prominent integrative theory of health behavior change (Prochaska & Velicer, 1997) that can also be used to understand smoking uptake during adolescence (Pallonen et al., 1998; Plummer et al., 2001; Velicer et al., 2007, 2013). The TTM posits many different causal relationships between its independent variables and mediators of smoking acquisition. While some research has examined the stages of smoking acquisition, decisional balance measures (i.e. pros and cons), and Self-Efficacy/Temptations as predictors of smoking outcomes longitudinally (Plummer et al., 2001), no studies have examined causal pathways between the processes of change and TTM mediators of smoking acquisition over time. As a result, there is a gap in the TTM literature on smoking acquisition.

Mediation analysis is a sophisticated quantitative method that can help researchers examine the purported causal pathways among the myriad TTM factors associated with smoking acquisition. Statistical mediation analysis (i.e. causal modeling) is often used in prevention research to investigate how and why two or more variables are related. The purpose of this study was to investigate causal pathways between the TTM's processes of change, its mediators and smoking acquisition in a four-wave longitudinal design. The models used in this study were informed by previous research that investigated similar causal pathways in 3-wave autoregressive mediation models of smoking cessation in adults (see Babbin, 2014). In addition to theoretical implications, this study has practical implications for future research.

Chapter 1: Overview of Studies

This dissertation is organized and presented in four papers. The first chapter introduces the Transtheoretical Model's (TTM) core components (i.e. stages of change, processes of smoking acquisition and mediators of change), and provides an overview of the mediation models used in this study. The second chapter examined causal relationships between the TTM's core constructs and smoking acquisition over 4 years. Different combinations of TTM variables (11 processes of change * 3 Mediators * 1 acquisition stage outcome= 33 total models) were investigated with a four-wave autoregressive single-mediator model analytic template. The templates for all the models that were examined are presented in the Appendix.

The purpose of chapter 3 was to refine, consolidate and extend conclusions from the previous chapter. All the models that appear in chapter 2 demonstrated evidence of statistical mediation were evaluated for the presence of statistical moderation in chapter 3. Multiple group analyses were used to determine whether the mediated pathways (i.e. indirect effects) were moderated by grouping variables. All of the models were longitudinal; all of the path models were built with structural equation modeling (SEM) software; and all manuscripts were prepared using APA style and formatting conventions.

Finally, the last chapter summarizes the conclusions from this work. Implications for future models and substance use prevention research were discussed.

The Transtheoretical Model

The TTM's core constructs have been shown to be predictive of behavior change in over 48 different health behaviors (Hall and Rossi, 2008), including alcohol

use (Babbin et al., 2011; Migneault, Pallonen, & Velicer, 1997), dietary fat (Rossi et al., 2001), condom use (Redding et al., 2015) and smoking acquisition (McGee et al., 2012; Pallonen et al., 1998; Plummer et al., 2001; Velicer, Redding, Anatchkova, Fava & Prochaska, 2007; Velicer, Redding, Paiva et al., 2013). However, the TTM has been most widely applied to smoking cessation (Hoepfner, Redding, Rossi, Pallonen, Prochaska, & Velicer, 2012; Norman, Velicer, Fava, & Prochaska, 1998; Noar, Benac, & Harris, 2007; Prochaska & Velicer, 1997; Prochaska et al., 2001; Sun et al., 2007; Velicer, Redding, Sun, & Prochaska, 2007).

In the context of smoking cessation, the core constructs of the TTM include the stages of change, the processes of change (e.g. dramatic relief, consciousness raising and self-liberation), decisional balance measures (i.e. the Pros and Cons), and Self-efficacy/ Temptations (Plummer et al., 2001; Velicer et al., 2007). An individual can move to any one of five stages: Precontemplation, Contemplation, Preparation, Action and Maintenance (Prochaska et al., 1992) at any time. The stages of change and TTM have significant implications for smoking interventions (Aveyard et al., 2001; Prochaska & DiClemente, 1982; Prochaska & Velicer, 1997; Prochaska, Velicer, Fava, Rossi, & Tsoh, 2001). The processes of change are the covert and overt actions people use at different junctures of the change process (Hoepfner et al., 2006; Sun et al., 2007; Velicer, Rossi, Prochaska, & DiClemente, 1996). The mediators are one's attitudes and beliefs about change. Decisional balance measures of the Pros and Cons of behavior change reflecting an individual's weighting of the perceived benefits relative to the risks of continuing to smoke (Velicer et al., 1985). Self-efficacy and situational temptations are inversely related measures of situation-specific confidence

(Velicer et al., 1990). That is, self-efficacy reflects one's confidence in being able to cope with high-risk situations without smoking, whereas situational temptations reflect one's urges to smoke in high risk situations (Velicer et al., 1990).

Smoking Prevention Measures

At this juncture, it is important to distinguish between the TTM measures applied to problem behavior change and those applied to prevention. The TTM has been established as an effective model of behavior change (Pallonen, 1998; Prochaska & Velicer, 1997) and has been shown to be applicable for smoking cessation in adults (Prochaska et al., 1988) as well as the smoking acquisition process in adolescents (Pallonen et al., 1998). The major advantage of using the TTM is the conceptualization of stage based interventions. TTM interventions are matched to the individual based on their stage of readiness to quit a problem behavior such as smoking (Prochaska et al., 1988; Velicer et al., 1993). TTM constructs and interventions, however, need to be adapted to assess the underlying motivational processes used by nonsmokers to either maintain their nonsmoking status or move towards trying smoking or starting to smoke (Huang, Hollis, Polen, Lapidus, and Austen, 2005; Pallonen et al., 1998; Plummer et al., 2001). Accordingly, several researchers re-conceptualized the stages and other TTM constructs to more accurately assess the processes involved with smoking acquisition (Krebs et al., 2006; McGee et al., 2012; Pallonen et al., 1998; Plummer et al., 2001).

This study utilized the TTM's Acquisition stages of change (aSOC) and other smoking prevention constructs to describe the underlying motivational processes used by adolescents who are thinking about trying cigarettes in the near future. The aSOC

construct describes three different stages that students can move through before they try smoking. The first stage is Acquisition Precontemplation (aPC), which includes those who have not tried cigarettes and do not intend to do so in the next 6 months. The second stage is Acquisition Contemplation (aC), which contains nonsmokers who are thinking about trying smoking within the next 6 months, and the final stage before trying cigarettes is Acquisition Preparation (aP), which consists of nonsmokers who are thinking about trying smoking in the next 30 days (Krebs et al., 2006; McGee et al., 2012; Pallonen et al., 1998; Plummer et al., 2001). These stages taxonomize different attitudes among nonsmokers during their initial thoughts about trying smoking and their intentions to try smoking in the future. The three stages do not represent a linear progression from nonsmoker to smoker, rather an individual may go through several cycles of thought or intention before actually trying to smoke (Huang et al., 2005; Plummer et al., 2001).

Other Stage Models

Although the TTM acquisition stages are used in the present study, there are several other models of smoking acquisition that merit some attention (Botvin et al., 1990; Flay, Ockene, & Tager, 1992; Leventhal & Cleary, 1980). For instance, Leventhal and Cleary (1980) reviewed findings and theoretical implications of previous studies concerned with initiation, maintenance, and therapy of cigarette smoking in children and adults and suggested that there were at least four stages of smoking acquisition: (1) preparation, (2) initiation, (3) becoming a smoker, and (4) maintenance. Flay and colleagues (1992) expounded on this and developed a five-stage model of smoking onset: (1) the Preparatory stage; (2) Initial trying stage; (3)

Experimental stage; (4) Regular smoking stage; and (5) Dependency/Addiction (Flay et al., 1992).

Leventhal and Cleary (1980) also listed three cessation stages: (1) dissatisfaction, (2) decision to stop, and (3) adoption and maintenance of the self-image of ex- or non-smoker, but they stopped short of discussing further what those stages entailed. Despite their differences, the general consensus between these theories is that progression from one stage to the next is linear and one-directional. Individuals who are not smoking or not thinking about smoking in the near future are in the early stages but progressing to the experimental stage means the person can never go back to not thinking about smoking, and therefore can either stay in this stage or move on to a higher stage (Botvin et al., 1990; Flynn, et al., 1992).

Due to the complex and interrelated nature of individual, social, and psychological factors that influence behavior change, researchers must also consider how to address these factors at different stages of change for any meaningful effect to be found on preventing the uptake of smoking. The TTM has several core constructs that may be grouped along a number of dimensions, such as the temporal domain (i.e. Stages of change), independent variable domain (i.e. Processes of Change), and the intermediate or outcome variable domain (i.e. Decisional Balance, Situational Temptations) (Velicer et al., 1990). The above review has only dealt with the conceptualization of stages of change. The following two sections introduce the independent and mediating variables for smoking prevention. These constructs are vital to understanding the causal influences on smoking acquisition at different stages of change.

Processes of Smoking Prevention

The TTM has identified 11 processes for smoking prevention (Krebs et al., 2006), 10 of which have also been used, operationalized differently, for smoking cessation (Hoepfner et al., 2006; Prochaska et al., 1988). The processes represent two broad dimensions of change, experiential and behavioral (DiClemente et al., 1991; Prochaska et al., 1988; Velicer et al., 1999). The experiential processes include Consciousness Raising, Dramatic Relief, Environmental Reevaluation, Self-reevaluation, and Social Liberation. Behavioral processes include Stimulus Control, Counter Conditioning, Reinforcement Management, Self-Liberation, and Helping Relationships. Refusal assertiveness was conceptualized as an 11th process specifically for smoking acquisition (Krebs et al., 2006). The fundamental difference between the cessation and smoking acquisition processes of change is that the former are designed to assess the smoker's thoughts, attitudes and behaviors as they progress through the stages of change towards action and maintenance for quitting smoking (Prochaska et al., 1988), whereas the latter focus on thoughts, attitudes and behaviors that would prevent the nonsmoker from moving to a later stage of change where they may actually try or start smoking (Krebs et al., 2006). The processes for smoking prevention are discussed further in Paper 2.

Decisional Balance and Temptations

As previously mentioned, the stages of change and process variables are used to describe different attitudes and behaviors evident at various stages of change. On the other hand, the decisional balance and temptations measures tap into the cognitive and affective factors involved in decision making. Decisional balance is composed of

two latent factors which measure one's subjective weighting of the importance of a set of positive (i.e. Pros) and negative (i.e. Cons) aspects of engaging in a behavior. The Pros and Cons have been shown to have a clear and consistent relationship with the stages of change for a wide range of behaviors (Hall & Rossi, 1998). The temptations measure is composed of four different situations where temptations to try smoking may increase. Previous research in samples of adolescents led to five distinct temptations to try smoking, (1) Positive/Social situations, (2) Negative Affect situations, (3) Peer situations, (4) Curiosity about smoking and (5) weight control (Plummer et al., 2001). Temptations to try smoking has been shown to have a positive linear relationship with the stages of acquisition (Pallonen, et al., 1998; Plummer et al., 2001). The decisional balance and temptations measures are discussed further in Paper 2.

Overview of Mediation Analysis

Mediation analysis is a statistical method used to investigate how and why two or more variables are related (MacKinnon, 2008). A mediator (aka indirect effect) implies a causal hypothesis whereby an independent variable (X) influences the mediating variable (M), which in turn, causes changes to the outcome (Y) or dependent variable (Baron & Kenney, 1986). Mediation analysis can be conducted with either cross-sectional or longitudinal data, however, longitudinal data provides the best evidence of the temporal ordering of effects between variables (Cole & Maxwell, 2003). Longitudinal models were used in the present research to examine the distal or ultimate indirect influence of many different processes of smoking acquisition. In general, the longitudinal relations between each construct across adjacent waves (e.g. X at Wave 1 \rightarrow M at Wave 2 \rightarrow Y at Wave 3) are examined

when testing for evidence of longitudinal mediation. These paths reflect the temporal ordering of the indirect effects on the outcome variable (Cole & Maxwell, 2003; Gollob & Reichardt, 1991). The present study utilized four-waves of data to investigate smoking acquisition over four years.

Moderated-Mediation

Models with multiple mediators, multiple independent variables, or multiple dependent variables almost always represent a more accurate and valid representation of statistical mediation (Hayes, 2013; MacKinnon, 2008; Preacher et al., 2007). Some researchers include static variables and demographic groups to examine whether mediational relationships change as a function of some moderating influence (Fairchild & MacKinnon, 2009; Wu & Zumbo, 2008). Demographic variables, such as age, gender, race/ethnicity, and education level are often tested, as these variables may potentially moderate the indirect influences, distal vs. proximal causes, and intermediate outcomes. Moderated-mediation is a general term used to describe whether the relationship between the independent variable and the mediator or the relationship between the mediator and outcome changes as a function of some moderating influence (Fairchild & MacKinnon, 2009; Hayes, 2013; Preacher et al., 2007; Wu & Zumbo, 2008).

More comprehensive models that test for moderated-mediation can provide valuable insight about the validity, consistency and generalizability of the statistical mediation models (Cheung & Lau, 2008; Hayes, 2013). Accordingly, moderated-mediation was assessed in Paper 3 to test for moderation in the mediational paths across different subgroups of gender and race. The results of those analyses were

important for two reasons. First, the results highlighted important relationships between several TTM variables and smoking acquisition. Second, the analyses provided stronger evidence about the generalizability of the findings. The analytic approach of the present study was adapted from the autoregressive models that evaluated longitudinal mediation of smoking cessation over three-time points (36 months) (Babbin, 2014; Babbin et al., 2017). In that study, several processes of cessation (e.g. Consciousness Raising and Dramatic Relief) were found to have been mediated by the Pros, Cons and Temptations and no evidence was found of moderated-mediation based on age, gender, or race (Babbin, 2014; Babbin et al., 2017).

Mediation and Substance Use Prevention

Mediation analysis is also relevant in the context of evaluating the efficacy of treatment components in randomized control trial (RCT) studies. A large number of studies have examined the influence of substance use prevention interventions on preventing smoking uptake in adolescents (Botvin et al., 1990; Hollis, et al., 2006; Hwang, Yeagley, & Petosa; MacKinnon & Dwyer, 1993; Velicer et al., 2013). For example, the Midwestern Prevention Project (MPP) found social norms among friends and beliefs about the benefits of drug use significantly mediated program effects that were designed to target alcohol, cigarette, and marijuana use (MacKinnon et al., 1991). Alcohol-use intentions were partially mediated by social norms and beliefs about the benefits of alcohol; however, perceived resistance skills, peer norms, and negative consequences of drug use did not mediate intentions to use (MacKinnon et al., 1991).

Other studies have found evidence of moderated-mediation, where various mediators of smoking such as normative beliefs, lifestyle incongruence, and commitment to not use drugs were moderated by the treatment method (McNeal et al. 2004). The authors indicated that the interventions were only successful when it was delivered by teachers, whereas when the treatment was delivered by specialists the interventions failed to have an effect on the mediators, suggesting that mediation could potentially be moderated by treatment or other variables.

Project Best

This study consists of a secondary data analysis from a school-based RCT that examined computer-tailored interactive interventions that were group specific (Velicer et al., 2013). One major advantage of using TTM interventions is that the interventions were tailored to address the needs of the individual in different stages of change (Hollis et al., 2005; Prochaska et al., 2004; Sun, Prochaska, Velicer, & Laforge, 2007; Velicer et al., 1993; 2013). Project BEST participants (N=4158) were middle school students recruited from 20 middle schools in Rhode Island (Velicer et al., 2013). Ten middle schools received the energy balance intervention and ten schools received the substance use prevention intervention. The energy balance group interacted with interventions aimed at increasing exercise, improving diet and reducing TV time. The substance prevention group received interventions aimed at reducing tobacco and alcohol use. This study utilized a subsample from of Project Best (N=1573); only data from the substance use prevention group was used. No data were included from the energy balance group. The substance prevention group were evaluated yearly from 6th grade – 9th grade and received five 30-minute tailored intervention sessions, with the

first occurring during the baseline assessment at the beginning of sixth grade. Students received three interventions approximately 2 months apart during the seventh grade and the final intervention occurred at the beginning of eighth grade. Students were last assessed during 9th grade.

An exploratory analysis of all the substance prevention group data revealed that the majority of adolescents (99.8%) were nonsmokers at baseline (Velicer et al., 2013). Thus, for the purposes of this dissertation, only nonsmoking students in aPC stage at baseline were included in this study (N=1573). All students received TTM-tailored prevention feedback messages that were based on the cluster profiles of nonsmoking students (see Velicer, Redding, Anatchkova, Fava, & Prochaska, 2007; 2013).

Purpose of This Study

Despite the importance of understanding causal factors and correlates of smoking uptake, little is currently known about causal relationships between TTM variables for smoking prevention and smoking acquisition. Studies have shown intentions to smoke in middle school can lead to smoking in early high school (Hollis et al., 2005; Huang, et al., 2005; Hwang et al., 2005; Velicer et al., 2007; 2013). There is thus a need for research that can better understand the causal mechanisms of smoking acquisition over time, as this could lead to the development of better interventions. The purpose of this study was to model longitudinal pathways between TTM variables and the stages of smoking acquisition to determine the most important causal mechanisms of change between early middle school and high school.

Based on discoveries from prior research with multiple groups of adult smokers (Babbin, 2014; Babbin et al., 2017), the present study also examines whether the indirect effects in the mediation models could change as a function of some demographic characteristics such as gender or race (i.e. Moderated-mediation). A Structural equation modeling (SEM) approach was used to construct the mediation models. SEM is the ideal approach for evaluating latent variable models with multiple groups, mediators, independent and dependent variables (Kline, 2005; MacKinnon, 2008). A latent variable is a hypothetical, unmeasurable or unobservable variable generated by two or more manifest variables, indicators, or effects that are hypothetically or theoretically related to each other (Kline, 2005), and latent variable models consist of measurement and structural sub-models. In this context of mediation analysis, the measurement and structural models represent the true decomposition of the total effects into direct and indirect effects (Iacobucci, Saldanha, & Deng, 2007; Fairchild & MacKinnon, 2009).

Research Aims

This research aims to increase our understanding of the complex causal relationships that underlie the uptake of smoking during adolescence. This work directly addresses several critical needs described in the NIH Roadmap science of behavior change meeting summary (2009; 2012), including: (1) the need to improve our understanding of the mechanisms of behavior change; (2) the value of taking a developmental perspective, and (3) the need for the development, dissemination, and

use of new methods. This dissertation addresses several important gaps in the literature on smoking acquisition with a longitudinal sample of adolescents. The specific aims of this study were:

1. To analyze 33 different single mediator models and determine which combination of variables provided evidence of statistical mediation. The independent variables (X) were 11 processes of change variables; the mediators (M), were the Pros, Cons and Situational temptations, and Smoking stage was the outcome variable (Y). (11 X * 3 M * 1 Y= 33 models).
2. To construct Multiple-mediator models that included all combinations of significant mediating variables from the significant single mediator model analyses.
3. To determine statistical mediation with multiple IVs and/or mediators.
4. To determine the extent to which the final mediation models were equivalent across subgroups of gender and race/ethnicity.

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Chapter 2

“Investigating the Mechanisms of Smoking Acquisition in Adolescents: Statistical Mediation with Single Mediators”

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In preparation for Multivariate Behavioral Research

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Abstract

The causes and correlates of smoking acquisition involve the complex interplay of environmental, behavioral and psychosocial factors (Flay et al., 2005; Hwang et al., 2004; Leventhal and Cleary, 1980). Investigating and comparing mechanisms of smoking acquisition will help researchers better understand causal relationships among variables that explain the uptake of youth smoking. The goal of this study was to assess statistical mediation of smoking acquisition using Transtheoretical Model (TTM) variables. Four waves of smoking acquisition stage were evaluated as the dependent variables in 33 different single-mediator models (11 TTM processes of smoking prevention * 3 mediators * acquisition stage). The data comes from a substance abuse prevention sample (N=1573) of nonsmoking middle school students from 10 Rhode Island schools followed over 4 years. The baseline sample was predominately white (66%), and split approximately equal with regards to gender (49% female). Models with Dramatic Relief, Social Liberation, and Stimulus Control showed evidence of statistical mediation through the situational temptations for smoking prevention. The bias-corrected bootstrap of the products of the indirect paths between the processes variables at time two and mediator at time 3 (a3 path) and the path between the mediator at time 3 and smoking acquisition at time 4 (b5 path) supported the mediation findings. The results from this study facilitate a better understanding of the causal relationships between TTM mechanisms and smoking acquisition during a critical period of early adolescence. Future studies may consider combining these models to assess multiple mechanisms in the model.

Keywords: Statistical Mediation Analysis; Smoking acquisition; Smoking onset;
Transtheoretical Model; Acquisition Stages of Change; Adolescence

Investigating the Mechanisms of Smoking Behavior Change: Single Mediator models of Smoking Acquisition

Tobacco use represents the largest preventable cause of disease and death in the United States (U.S. Department of Health and Human Services [USDHHS], 2010). Preventing the uptake of cigarette use during adolescence is of particular interest because smoking is linked to numerous poor health outcomes such as heart disease and lung cancer. Despite the extreme consequences of smoking, more than 3,800 young people under the age of 18 smoke their first cigarette each day and over 2,100 youth become addicted to cigarettes (USDHHS, 2014). It is important that new research can investigate the underlying causal factors that drive young people to start smoking.

Much research has been done to identify a plethora of biological, environmental, personal, behavioral, and psychosocial factors of smoking and the continued use of cigarettes (Flay et al., 2005; Huang et al., 2005; Leventhal and Cleary, 1980; Velicer, Redding, Anatchkova, Fava, & Prochaska, 2007). One thing that is clear is that adolescence is the developmental window when they are most susceptible to start smoking as adults (Hwang, Yeagley, & Petosa, 2004). Among young teens in the early stages of smoking acquisition, curiosity, negative affect, weight control, as well as the pros and cons of smoking have been found to be among the most salient predictors of smoking uptake in the late stages of high school (Kremers, Mudde & De Vries, 2004; Pallonen, et al., 1998; Plummer et al., 2001). Among the myriad factors and causal pathways among them, the timing of treatment

interventions that students receive have important indirect effects on smoking outcomes.

The Transtheoretical model (TTM) is a well-known integrative model that comprises some of the most salient constructs and predictors of health behavior change (Hall & Rossi, 2008; Hoepnner et al., 2006; Pallonen, et al., 1998; Plummer et. al., 2001; Velicer & Prochaska, 2000). The model was originally developed to understand how individuals became motivated to quit smoking (Prochaska & DiClemente, 1983), however, the model has been adapted numerous times to target different behaviors that researchers either want to decrease such as smoking (Prochaska, Velicer, DiClemente, & Fava, 1988) and heavy drinking (Migneault et al., 1998), or increase such as healthy eating and exercise (Naa, et al., 2012; Schumann, et al., 2002). Furthermore, the TTM model for prevention is used to stop the acquisition of an unhealthy behavior. However, much less work has been done to empirically investigate TTM constructs for prevention. Throughout this study, the TTM for Prevention will be discussed, but a more thorough review of the TTM for cessation can be found elsewhere (see Prochaska & Velicer, 1997).

The TTM for prevention has several core constructs (stages of change, processes of change, decisional balance & temptations). Firstly, behavior change is theorized to occur over three stages of change. The acquisition stages of change (aSOC) describes nonsmokers' intentions to start smoking in the future. The acquisition precontemplation (aPC) stage consists of those who have never smoked and have no intentions to do so in the next six months. The acquisition contemplation (aC) stage consists of never smokers who were thinking about trying smoking within

the next six months. The acquisition preparation (aP) stage consists of never smokers who were planning to try smoking in the next 30 days. People can stay in or move to a different stage at any time. The acquisition stages have been used to highlight some of the most important psychological constructs and mediators of smoking acquisition during adolescence (Pallonen et al., 1998).

Second, there are a number of cognitive and behavioral processes of prevention that are used at different stages of acquisition. These cognitive and behavioral processes are defined as activities that facilitate changes in thinking and attitudes about behavior change (Krebs et al., 2006; Prochaska et al., 1988). At this juncture, it is important to note several key differences between the processes of change for prevention and cessation, as they have similar subscale labels, but are different constructs (Hoepfner et al., 2006; Krebs et al., 2006; Plummer et al., 2001). The process variables for cessation have been found to have a correlated higher-order factor structure representing two broad dimensions of change, *Experiential* and *Behavioral* (DiClemente et al., 1991; Prochaska et al., 1988; Velicer et al., 1999). Experiential processes include, Consciousness Raising, Dramatic Relief, Environmental Reevaluation, Self-reevaluation, and Social Liberation. Behavioral processes include, Stimulus Control, Counter Conditioning, Reinforcement Management, Self-Liberation, and Helping Relationships. The processes for cessation reflect strategies for smoking cessation, whereas the processes for prevention were modified both operationally and conceptually to apply to smoking prevention research (Krebs et al., 2006). The processes subscale labels for smoking prevention are presented in Table 2.1 and items are included in Appendix E. In addition, there is an

11th prevention process called Refusal Assertiveness reflecting individual's ability to avoid social pressures to try smoking. Refusal Assertiveness falls into the behavioral domain (Krebs et al., 2006).

The TTM's core constructs also include decisional balance and temptations measures. They are key intermediate/outcome measures (aka mediators) that are theoretically causally proximal or intermediate to smoking and other behavior change outcomes (Huang et al., 2005; McGee et al., 2012; Plummer et al., 2001; Prochaska & DiClemente, 1983; Prochaska, DiClemente, & Norcross, 1992; Prochaska & Velicer, 1997). The decisional balance measures are the pros and cons of smoking prevention. Some perceived pros would be the social benefits of smoking, such as fitting in, increased popularity and so on. An example of a con would be the perceived health risk associated with smoking. Adolescents who are not thinking about trying smoking (aPC stage), are more likely to value the cons than the pros of smoking (Pallonen, 1998). Temptations reflect situation-specific urges to try smoking in difficult situations (McGee et al., 2012). Pallonen (1998) found in the earlier stages of smoking acquisition, social situations and curiosity were the most salient temptations, but negative affect became more important in the later stages. Plummer et al. (2001) found negative affect, positive social situations, habit strength (craving), and weight control were salient temptations subscales among adolescent smokers, but also found curiosity and boredom as important temptations for trying smoking among nonsmoking adolescents.

Mediation Analysis

A mediator is a third variable that explains the relationship between an independent and dependent variable. Mediation analysis is a sophisticated statistical method used in the social and behavioral sciences to demonstrate the causal sequence of indirect effects on an outcome. That is, the effects of an independent variable (X) on the dependent variable (Y), are mediated by a third variable (M) called a mediator (aka intervening variable). The causal relationship between X and Y is said to be an indirect effect if it goes thru M. In other words, instead of X causing Y directly, X is causing M, and in turn M causes Y (Baron & Kenny, 1986; MacKinnon, 2008). Because mediators are hypothesized to cause changes in the dependent variables, mediation models are also referred to as causal models (Baron & Kenny, 1986).

Longitudinal Mediation Models

There are several different types of longitudinal models for mediation such as autoregressive (AR) mediation, latent difference score models and longitudinal growth curve models (GCM). They all provide different strengths and weaknesses in different research contexts (MacKinnon, et al., 2007; Selig, & Preacher, 2007; Wu & Zumbo, 2008), however, one of the greatest strengths of the AR model is its ability to concomitantly test all of the mediated effects (i.e. indirect effects) and the standard errors for these pathways in the model (Cole & Maxwell, 2003; Iacobucci, Saldanha, & Deng, 2007). A structural equation modeling (SEM) approach can be employed to estimate the regression paths, standard errors, and error terms in the models.

Prior research has utilized AR models to assess longitudinal relationships among TTM variables and smoking cessation. A dissertation study by Babbin (2014; Babbin et al., 2017) evaluated over 30 statistical mediation models to determine causal

relationships among TTM variables and smoking cessation across three stages of smoking cessation in adult smokers: Precontemplation, Contemplation and Preparation. The study evaluated different types of autoregressive models (i.e. AR I, AR II, and AR III) with three waves of data. The AR II template was shown to fit the data the best compared to all other templates and the models were used to demonstrate that smoking outcomes were mediated through the Pros, Cons and situational temptations of smoking. Specifically, Consciousness Raising, Dramatic Relief, Self-Reevaluation, and Social Liberation were found to be some of the most important processes of cessation for people in the pre-action stages of smoking cessation.

The Current Study

It is well established in the literature that the causes and correlates of smoking acquisition involves a complex interplay of factors (Flay et al., 2005; Hwang et al., 2004; Leventhal and Cleary, 1980). However, no studies have investigated TTM variables in longitudinal mediation models of smoking acquisition. Far more research has examined mechanisms of smoking cessation outcomes with adults (Babbin, 2014; Babbin et al., 2017; Hoepfner, Goodwin, Velicer, Mooney, & Hatsukami, 2008; Hwang, Yeagley, & Petosa, 2004; Myers & Macpherson, 2009; Velicer & Prochaska, 1999). Thus, current knowledge about the underlying causal influences of TTM mediators on the uptake of smoking is limited. Given this important gap in the literature, this study aimed to explore many different causal pathways between TTM independent variables and mediators in longitudinal models of smoking acquisition.

The present study used an Autoregressive (AR II) model template with four waves of data to investigate smoking acquisition. Figure 2.1 illustrates various

contemporaneous relationships along with various longitudinal relations between variables, just one lag apart (Cole & Maxwell, 2007; Gallob & Reichardt, 1991, MacKinnon, 2008). This model assumes the values of a variable in the future depend on the values from previous time points and considers longitudinal stability in the model with stability measures for the same variable across time (e.g. S_1, S_2, S_3). The longitudinal direct effect paths are denoted by the coefficient c' between adjacent waves (E.g. X_1 to Y_2 and X_2 to Y_3). A direct effect measures the extent to which the dependent variable changes when the independent variable increases by one unit and the mediator variable remains unaltered (Baron & Kenny, 1986; MacKinnon, 2008). Figure 2.1 also shows both the contemporaneous and longitudinal relationships between X and M, which were denoted by the coefficient a_k path (k represents the path at different waves). The longitudinal mediated effects—the parameters that provide the best evidence of mediation—are the indirect effect paths between different waves (e.g. a_1b_3 , reflects the first lag mediated effect, and a_3b_5 , in the second lag). Finally, the contemporaneous relations between variables imply various temporal relationships between the independent variable, mediator, and dependent variable could exhibit convincing evidence of partial mediation. Partial mediation is the case in which the regression coefficient of the c path estimate from X to Y is reduced in absolute size but is still different from zero when the mediator is introduced (see MacKinnon, 2008). However, because the goal of this study was to specifically examine the statistical significance of the longitudinal mediation pathways, the contemporaneous mediation pathways were not examined for evidence of mediation.

METHODOLOGY

Subjects

The secondary dataset comes from Project Best, a school-based RCT study that was conducted between 2007-2011 (Velicer et al., 2013). Middle school students were recruited from 20 middle schools in Rhode Island. Participating schools were matched on available school-level data to form matched pairs of schools that were then randomized to each group. The study had two treatment arms with each group serving as the comparison group for the other. Ten middle schools received an energy balance (EB) intervention, and ten schools received the substance use prevention (SP) intervention. The baseline assessment session and the first intervention session were administered at the beginning of sixth grade (2007–2008), where students received three 30-min computerized TTM-tailored intervention sessions approximately 2 months apart during seventh grade (2008–2009), and the final intervention session occurring at the beginning of eighth grade (2009–2010). Finally, students were last assessed during 9th grade. Consent and other human subject protocols were approved by the University of Rhode Island Institutional Review Board, and research was conducted per APA ethical guidelines. Additional details about the original study, including full sample demographics, procedures, and outcomes for both treatment arms can be found elsewhere (see Velicer et al., 2013).

This study's analyses utilized only the SP intervention treatment arm because the processes of change for smoking were only measured in the SP intervention group, which were vital to addressing the aims and objectives of this study. Accordingly, the following sample description is of the SP group. Among the baseline sample of sixth

grade nonsmokers in aPC ($N=1573$), the mean age was 11.25 ($SD=0.50$), 51% were male, 66.2% white, 15.2% mixed, 7.6% Hispanic, and 4.5% Black.

Measures

Acquisition Stages of Change. In the present study, participants who reported that they were not thinking of trying smoking/ in the next 6 months were classified into the Acquisition Precontemplation (aPC) stage. At follow up evaluations, students were asked again about their intentions to try smoking and could have been classified into either aC (thinking about trying smoking in the next 6 months) or aPR (planning to try smoking in the next 30 days) or as smokers, if they had actually tried smoking.

Independent Variables

Processes of Change for smoking prevention. Each of the processes of change was conceptualized by latent variables identified with two or three items. Although latent factors are usually identified by three or more indicator variables, it is possible and sometimes necessary to construct reliable factors with just one or two items (Albright & Park, 2009). Participants were asked to rate how often they used each process in the last month on a 5-point Likert scale ranging from 1 (Never) to 5 (Repeatedly). The reliability and validity of the processes of change for prevention have been examined in previous studies (Krebs et al., 2006; Pallonen, 1998).

Mediators

Decisional Balance. Each scale includes multiple items for the pros and the cons of a behavior. The five items of the pros scale measured advantages of smoking (e.g. smoking makes kids get more respect from others, kids who smoke have more friends, kids who smoke go out on more dates). The five items of the cons scale

assessed disadvantages of smoking (e.g. smoking stinks, smoking can affect the health of others, smoking cigarettes is hazardous to people's health). The items in the present study utilized a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Decisional Balance Inventory for Smoking Prevention has demonstrated sufficient factorial invariance and good reliability (Anatchkova et al., 2006; Hoepfner et al., 2012; Plummer et al., 2001). Composite scores of the Pros and the Cons subscales represented latent measures of its respective construct in the mediation models.

Situational Temptations. The six-item Temptations to Try Smoking Scale consisted of two correlated subscales: Positive Social Situations and Curiosity about Smoking/Stress (three items for each scale). The Positive Social Situations scale (e.g. While talking to my friends, When I am having a good time) and Curiosity about Smoking/Stress scale (e.g. When I am stressed, When I want to know how a cigarette tastes) utilized a 5-point Likert scale ranging from 1 (not at all tempted) to 5 (strongly tempted). The scale has demonstrated sufficient factorial invariance (strong invariance) and good reliability (Anatchkova et al., 2006; McGee et al., 2012; Plummer et al., 2001). Composite scores of the Temptations subscales represented the latent measure of Temptations in the mediation models.

Outcome Measure

Stages of Change for Smoking Acquisition. Students were asked if they were thinking about or planning to try smoking within the next 30 days (acquisition preparation stage) or 6 months (acquisition contemplation stage). Students who reported that they were not thinking of trying smoking in the next 6 months were

classified into the acquisition precontemplation (aPC) stage. Smoking acquisition outcomes were measured on an ordinal 0-3 scale where each level was based on overall stage category at each time point. Because all of the participants at baseline were in the aPC stage (N=1573), this resulted in a structural zero (0= structural 0, 1=aPC) in the first time point in all of the mediation models. However, all subsequent time points modeled students' movement to a different stage of smoking acquisition (i.e. aC/aP=2, Smoker=3). Table 2.2 describes all study variables over time showing that although reasonable proportions of the baseline sample were available for follow-up evaluations, missing data at follow up time points was an issue.

Missing Data

Although the retention of the baseline sample into the final wave of this study was high (76%), missingness could have been related to one or more covariates employed in the statistical model or to other unused variables available in the dataset, which could introduce bias into the models (Schafer & Graham, 2002). Therefore, Full Information Maximum Likelihood (FIML) was utilized in Mplus software to correct for any bias due to covariate dependent missingness that could have been related to the variables included in the model.

Statistical Analysis

Model Fit statistics/Assessment of Mediation

Statistical mediation analysis was used to test the causal hypotheses between the Processes of Change variables and mediators of smoking on smoking acquisition. The present study assessed longitudinal mediation across four waves of data in 33 single mediator models. The mediation models were constructed in two phases. First,

the goodness of fit of the model was assessed. A good fitting model indicates that the underlying measurement model fits the data very well. The following indices are commonly used to assess model fit: likelihood ratio chi-square (χ^2), Comparative Fit Index (CFI; Bentler 1990), Root Mean Squared Error of Approximation (RMSEA; Steiger & Lind, 1980), and standardized root mean squared residual (SRMR). The likelihood ratio chi-square provides a test for fit of the model based on the chi-squared distribution. The CFI statistic indicates the relative improvement in the fit of the measurement model compared to a statistical baseline model. A value of .90 indicates good fit and estimates $\geq .95$ indicate excellent fit (Kline, 2005). The RMSEA is a parsimony-adjusted, absolute model fit index that accounts for the degrees of freedom in the model and sample size. Estimates below .10 indicate acceptable fit, $< .05$ suggests good fit and a value of zero indicates the best fit (Kline, 2005). The SRMR is an estimate of the standardized differences between the observed and the predicted covariances. SRMR residuals should be close to zero for a very close fit, but estimates below .08 indicate acceptable model fit (Kline, 2005). The mediation models that have the best model fit using the criteria previously mentioned would be retained.

Measures of effect size provide an indication of the size and meaningfulness of the effect. To date, there is no consensus on which estimates best represent effect sizes for statistical mediation analysis (Fairchild, MacKinnon, Taborga, & Taylor, 2009; Preacher & Kelly, 2011). However, simulation studies have shown that correlation and standardized coefficient measures have low bias even in small samples (Lau & Cheung, 2012; MacKinnon, Warsi, & Dwyer, 1995). For those reasons, the standardized coefficients for a_1 , b_1 and the product of the standardized coefficients

were reported (MacKinnon, 2008). The absolute values for R^2 estimates were interpreted as comparable to a small (.01), medium (.06), or large effect size (.13) (Cohen, 1988). The second phase of the analysis was to validate the accuracy of the mediated effect estimates. A bias-corrected bootstrap analysis was used to calculate the 90% confidence intervals (CI) of the distribution of the mediated effects between specific indirect paths, a_1b_3 and a_3b_5 (Fairchild et al., 2009). This bootstrap method adjusted each bootstrap sample for potential bias in the estimate of the statistic (MacKinnon et al., 1995). The 90% CIs were the values of the mediated effects at the 5th and 95th percentiles in the distribution of the bootstrapped mediated effects. If the confidence limits did not include zero, there was additional evidence of statistical mediation (MacKinnon, 2008).

Results

Creation and Fit Assessment of Mediation Models

As a first step, descriptive analyses were performed to check for extreme skewness and kurtosis values for the study variables (West, Finch, & Curran, 1995). Independent samples t-tests were performed to check for mean differences related to gender. With the exception of Helping Relationships, Pros, and Temptations, we found significant mean differences for the study variables at baseline, with females reporting slightly higher mean scores compared to males (all $p < .05$) on Counter Conditioning, Consciousness Raising, Dramatic Relief, Environmental Reevaluation, Refusal Assertiveness, Reinforcement Management, Stimulus Control, Social Liberation, Self-Reevaluation, and Cons. Table 2.1 contains the descriptive statistics and t test results by gender. Table 2.1 contains the descriptive statistics for all study variables across time. Sample retention was high (73%) from baseline to the final wave of the study.

SEM was employed with Mplus 7.11 software (Muthen, and Muthen, 2013) to develop the single mediator models. An autoregressive mediation model (II) autoregressive mediation model was developed to assess mediation based from suggestions from Cole and Maxwell (2003) and MacKinnon (2008). There are six key characteristics to the autoregressive mediation model II (MacKinnon, 2008). First, relations are modeled one lag apart (e.g., 12 months to 24 months). Second, relations between the same variables over time are modeled to assess stability (the s coefficients). Third, the model includes regression paths that describe longitudinal mediation (e.g., independent variable at time 1 to mediator at time 2, independent variable at time 1 to dependent variable at time 2). Fourth, covariances among the

variables at the first wave are estimated. Fifth, covariances among error terms are estimated at each wave. Sixth, relations between the independent variable and mediator, as well as mediator and dependent variable, are modeled. This is called contemporaneous mediation; the purpose of these paths is to help account for change that occurs between the time points. With the autoregressive model II framework selected, all 33 single mediator models were created. The template for the autoregressive mediation model II is included in Figure 2.1.

Model Fit Statistics. The series of 33 mediation models (11 processes * 3 mediators * 1 outcome) were successfully created. All of the models were conducted using ML to estimate missing data. Fit statistics from the ML models are included in Table 2.3. Models with Pros of Smoking or Cons of Smoking as mediators, demonstrated good fit, with CFI values consistently above 0.90 and RMSEA values consistently below 0.10. Models with Situational Temptations as the mediator also demonstrated very good CFI values, but had slightly higher RMSEA values, with CFI values consistently above 0.90 and RMSEA values consistently below 0.10.

Assessing Statistical Mediation

To assess the models for evidence of statistical mediation, the longitudinal regression paths estimated in SEM were evaluated. The mediation pathway (process at Time 1 to mediator at Time 2, a_1 , mediator at Time 2 to the outcome at Time 3, b_3 ; and process at Time 2 to mediator at Time 3, a_3 , mediator at Time 3 to the outcome at Time 4, b_5) within each model was assessed in two steps. First, the statistical significance of each path (e.g. a_3 and b_5 in Figure 2.1) was assessed. Second, a bias-corrected bootstrap procedure in Mplus was employed to estimate the asymmetric

confidence intervals for the product of these paths. Several diagrams are included for models where the mediation pathway demonstrated a medium or greater effect size.

Statistical Mediation with Pros of Smoking as Mediator. Unstandardized longitudinal regression paths describing the mediation pathway through the Pros of Smoking are included in Table 2.4. No processes demonstrated statistical significance for both components of the mediation pathway. Since none of the Processes of Prevention demonstrated evidence of statistical mediation with the Pros of Smoking as a mediator, the products, asymmetric confidence intervals, and products of standardized coefficients were not assessed.

Statistical Mediation with Cons of Smoking as Mediator. Unstandardized longitudinal regression paths describing the mediation pathway through the Cons of Smoking are included in Table 2.4. No Processes demonstrated statistical significance for both components of the mediation pathway. Since none of the Processes of Prevention demonstrated evidence of statistical mediation with the Cons of Smoking as a mediator, the products, asymmetric confidence intervals, and products of standardized coefficients were not assessed.

Statistical Mediation with Temptations as Mediator. The unstandardized longitudinal regression paths describing the mediation pathway through the Situational Temptations to Try Smoking are included in Table 2.4. Three Processes demonstrated statistical significance between a_3 and b_5 . These Processes, with unstandardized regression paths, were: Dramatic Relief ($a_3 = -0.611$, $b_5 = 0.033$); Self-Liberation ($a_3 = -0.929$, $b_5 = 0.031$); and Stimulus Control ($a_3 = -0.677$, $b_5 = 0.031$).

Products, confidence intervals, and products of standardized coefficients are included in Table 2.5. All three of the previously identified Processes had confidence intervals that did not include zero: Dramatic Relief (-0.066, -0.001; std. product = -0.033, small effect); Self Liberation (-0.077, -0.005; std. product = -0.041, small effect); and Stimulus Control (-0.069, -0.003; std. product = -0.036, small effect). These three Processes of Prevention demonstrated evidence of statistical mediation with Temptations as a mediator.

Discussion

Because of the dearth of studies examining Transtheoretical model (TTM) mechanisms of smoking acquisition during adolescence, the overarching objective of this research was to advance our understanding of the underlying processes and factors that influenced 6th grade nonsmoking adolescents to consider and start to smoke over time. The TTM was the guiding theoretical framework used to elucidate the distal mediating effects of the Pros, Cons, and Temptations to try smoking between various Processes of Prevention and smoking acquisition. Advanced statistical mediation analyses were utilized to investigate variables hypothesized to underlie changes in smoking onset. A total of 33 single-mediator models were successfully conducted for participants in aPC stage of smoking at baseline. All the models utilized an AR II mediation model (MacKinnon, 2008), had four time points, and employed maximum likelihood (ML) methods for missing data. With the exception of Refusal Assertiveness, all of the models demonstrated good fit (CFI >.90, RMSEA <.08, SRMR<.08), with a total of three models demonstrating evidence of statistical mediation with Situational Temptations. None of the models with Refusal Assertiveness as the independent variable (IV) met the appropriate model fit criteria for the SRMR (>.10), which meant that the measurement model was too unstable, resulting in imprecise standard errors. The standard errors are important as these estimates underlies the assumption that the products of *a* and *b*, has a normal distribution (MacKinnon, Lockwood, & Williams, 2004). Given that more information was needed in order to explain the high amount of variation in the model, mediation was not evaluated in models of Refusal Assertiveness. Nonetheless, the other process

subscales have consistently been shown to be strong predictors of smoking cessation in adults (Rossi, Prochaska & DiClemente, 1988; Sun et al., 2007; Wilcox, Prochaska, Velicer, & DiClemente, 1985). These results are similar to what other TTM studies have found with smoking cessation as the dependent variable in adults (Babbin, 2014; Babbin et al., 2017).

Two specific indirect longitudinal pathways between the process variables at time points 1 and 2), mediators at time points 2 and 3), and acquisition stage as the outcome at time points 3 and 4), were the focus of the present study. Several additional paths that were important to mediation, but not assessed, were the direct effects between the process variables at baseline to stage at subsequent time points. These paths described the relations from the independent variables to the dependent variables, adjusted for the effects of the mediators. A robust mediator resulted in very small direct effects on the outcome variable. In the present study, these effects were consistently very small.

Models with Decisional Balance: Pros or Cons as the Mediator

Both the Pros and Cons were hypothesized as potential mediators of smoking acquisition however neither showed evidence of longitudinal mediation on the relevant *a* and *b* paths. The Pros represent positive or appealing aspects of cigarette smoking (e.g. to increase popularity), whereas the Cons represent negative or unappealing aspects of cigarette smoking (e.g. bad breath). The Cons at baseline were much higher than the pros, indicating not surprisingly that students in aPC value the Cons over the Pros of smoking. However, none of the processes for smoking prevention were found to demonstrate evidence of statistical mediation through the

Pros or Cons. Models with the Pros demonstrated that smoking acquisition in 9th grade was significantly and positively associated with the Pros in 8th grade, but none of the processes variables were related to the Pros in any grade. By contrast, Reinforcement Management, Self-Reevaluation, Social Liberation and Stimulus Control were negatively associated with the Cons of smoking in 8th grade. However, the Cons were not related to smoking in 9th grade. These findings were surprising given that other studies have shown decisional balance measures for smoking cessation mediated several processes of change for adults in the early stages of smoking cessation. Babbin (2014; Babbin et al., 2017) found Consciousness Raising, Dramatic Relief, Self-Reevaluation, and Social Liberation demonstrated evidence of mediation through the Pros and Environmental Reevaluation, Self-Reevaluation, Social Liberation, Helping Relationships and Self Liberation demonstrated evidence of mediation through the Cons for people in precontemplation stage of cessation.

Models with Situational Temptations as the Mediator

Three Process subscales in 7th grade, Dramatic Relief, Self-Liberation and Stimulus control, were found to demonstrate evidence of statistical mediation through Temptations to try smoking in 8th grade (a path) and Temptations was predictive of smoking acquisition in 9th grade (b path). However, there was no evidence of longitudinal mediation at earlier time points. This finding may suggest that 6th grade is simply too early to see much changes in intentions to start smoking over time.

All three processes had a very small indirect effect on smoking acquisition over time. The R^2 effect size estimate was used to quantify the strength of the mediation relationships. The point estimate was obtained from the bootstrap analyses

of the standardized product (*ab*). The absolute value of the point estimates were interpreted like correlation estimates, such that the product of standardized paths that were $\geq .02$ indicated a small effect, $\geq .06$ was considered medium, and estimates $\geq .13$ were considered as large effects. The indirect effect estimates from largest to smallest effects were Self-Liberation (-0.041), Stimulus Control (-0.036) and Dramatic Relief (-0.033). Each variable had very small indirect effects on preventing increases in intentions to start smoking over time. These findings provided valuable insight about the distal impact of several important behavioral and cognitive-affective factors associated with the uptake of smoking during adolescence. Self-Liberation is the belief that one can stay committed to not smoking. Self-Liberation in the 7th grade was negatively associated with Temptations to try smoking in 8th grade. In addition, the small indirect effect suggests that higher levels of commitment to not smoke was associated with lower Temptations to try smoking, which in turn significantly reduced the likelihood of thinking about smoking or initiating smoking in 9th grade. Stimulus Control involves managing situations or people that could tempt someone to try smoking. Stimulus control in 7th grade was negatively associated with Temptations, suggesting that high levels of stimulus control reduced students' Temptations, and in turn reduced the likelihood they would start thinking about or try smoking in 9th grade. Dramatic relief reflects increased emotional awareness of the risks of smoking. Dramatic relief in 7th grade was negatively associated with Temptations in 8th grade and led to a small reduction in smoking acquisition in 9th grade. This finding suggests a positive emotional connection to remaining smoke-free is an important mechanism that reduces Temptations to try smoking and smoking uptake.

Taken together, these findings suggest that a few behavioral and cognitive processes of change had small effects on preventing smoking over four years. Thus, it stands to reason that future interventions continue encouraging students to make a commitment to not try cigarettes, stay away from situations or people who may tempt them to try smoking, and to maintain their emotional awareness of the risks of smoking. More research is needed to better understand the ways in which all of these processes may influence smoking acquisition over the course of adolescence.

The primary purpose of this study was to observe longitudinal mediation, however, the contemporaneous paths in the models were significant and merit some attention. All 33 models evaluated in the present study showed evidence of contemporaneous mediation (see Appendix for figures). The contemporaneous paths are in essence, cross-sectional models with one wave of data. This pattern of mediation provides some evidence of causal relationships between variables; however, it is not a true test of the temporal ordering between the process variables and mediators influence on each other (e.g. X at Time 1 influences M at Time 2, which influences Y at Time 3). Figure 2.1 contains the contemporaneous paths (the vertical a paths and b paths) between independent variables and mediators at each time point.

Limitations

This study has a number of practical and methodological limitations. The use of secondary data with missing data represented the biggest limitation to the present study in a number of ways. First, the current data was limited to only one treatment group. Since there was no control group to serve as a statistical control, this prevented some direct comparisons between groups. These statistical mediation analyses were

unable to determine the effect of the TTM interventions that were delivered to the sample at multiple waves. A suitable control group that received either no intervention or a completely different treatment modality would have allowed us to determine whether smoking acquisition was influenced by the intervention group status.

Second, the diversity of the sample was suboptimal. Only 20 participating schools from Rhode Island were included (Velicer et al., 2013). Although there was a reasonable distribution based on gender (51% male), nearly two-thirds of the sample was white, with the next highest category being mixed race (15%). A more diverse sample, with more participants from different races and ethnicities, would improve the generalizability of these findings.

Third, there were several methodological limitations with the data and some measures. Measures for the process variables and mediators at the fourth wave were unavailable. Pragmatic limitations using the stages of smoking acquisition as the dependent variable prevented an ideal longitudinal design. The smoking outcome is an important component in mediation, however, at baseline the stage variable was limited only to students in aPC and there were only three higher levels students could potentially move into over time. Moreover, since so few students moved to higher stages of acquisition over time, there was little variation in the dependent variable, which may have caused convergence issues with some of the models. Furthermore, the measures between each time point were not equally spaced for all schools across all years. Several practical restrictions arose when collecting data in some school districts (e.g. teacher schedules, working computers labs, etc.), that limited the precision of our

school-level assessment and intervention schedules across years. Conceivably, this could have introduced some bias into the study.

Finally, there were several patterns of missingness that could have biased the results (Shafer & Graham, 2002). The data were assumed to be missing at random (MAR), however this type of missingness could be related to one or more covariates employed in the statistical model or to other unused variables available in the dataset (Schafer & Graham, 2002). However, the FIML algorithm was used to correct for any bias due to covariate dependent missingness that was related to the variables included in the model.

Future Directions

More complex models involving two or more processes and multiple mediators should be investigated. Future studies may choose to adapt the models or continue using the same AR II framework to examine group differences in the models by incorporating moderators into the design. Moderated-mediation is used to investigate whether mediational relationships change as a function of some moderating influence of static variables such as age, gender, race/ethnicity, and education level (Fairchild & MacKinnon, 2009; Wu & Zumbo, 2008). Testing for the influence of moderated mediation will provide valuable insight about the validity, consistency and generalizability of the statistical mediation models (Hayes, 2013).

Conclusions

This study found two behavioral Processes and one cognitive-affective Process was mediated by Temptations to try smoking in predicting smoking uptake in young middle school students. Dramatic Relief, Stimulus Control and Self-Liberation were

the most salient Processes in the prediction of smoking acquisition over four years. This study increases our knowledge of important causal mechanisms of smoking acquisition. These findings may lead to the improvement and refinement of smoking prevention interventions. Follow up studies may benefit from including additional manifest variables or developing a better dependent variable for smoking acquisition.

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Tables.

Table 2.1 Independent samples t-test results for all TTM variables between males and females at baseline

Study variables at baseline	Male (N=791)		Female (N=760)		t value
	M	SD	M	SD	
Counter Conditioning	4.75	0.70	4.82	0.49	-2.30*
Consciousness Raising	4.36	0.93	4.51	0.72	-3.40***
Dramatic Relief	4.17	1.04	4.53	0.75	-7.66***
Environmental Reevaluation	4.23	1.00	4.30	0.91	-2.10***
Helping Relationships	4.28	0.92	4.38	0.78	-1.49
Refusal Assertiveness	4.45	0.85	4.53	0.69	-2.05*
Reinforcement Management	3.94	1.24	4.07	1.17	-2.09*
Stimulus Control	4.48	0.90	4.58	0.71	-2.45**
Self-Liberation	4.52	0.87	4.67	0.65	-3.79***
Social Liberation	4.44	0.88	4.52	0.69	-2.20*
Self-Reevaluation	4.64	0.82	4.78	0.57	-4.05***
Pros	7.11	2.76	6.95	2.71	1.10
Cons	22.74	3.40	23.16	2.92	-2.59**
Temptations	7.01	2.80	6.94	2.38	0.54

Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 2.2. Study variables means and standard deviations at baseline and over time

Variables	Time 1			Time 2			Time 3			Time 4		
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>
Counter Conditioning	1573	4.78	0.62	1443	4.76	0.63	1243	4.62	0.85			
Consciousness Raising	1573	4.43	0.85	1443	4.34	0.91	1243	4.25	1.08			
Dramatic Relief	1573	4.34	0.93	1443	4.28	1.00	1243	4.23	1.12			
Environmental Reevaluation	1573	4.25	0.97	1443	4.22	1.05	1243	4.26	1.10			
Helping Relationships	1573	4.32	0.87	1443	4.23	0.96	1243	4.22	1.08			
Rationalization	1573	4.48	0.79	1423	4.44	0.85	1172	4.36	0.98			
Reinforcement Management	1573	3.99	1.21	1443	3.92	1.27	1243	3.97	1.34			
Stimulus Control	1573	4.52	0.83	1443	4.43	0.93	1243	4.31	1.06			
Self Liberation	1573	4.58	0.79	1443	4.50	0.86	1243	4.36	1.05			
Social Liberation	1573	4.47	0.80	1443	4.62	0.81	1243	4.33	1.04			
Self Reevaluation	1573	4.70	0.73	1443	4.43	0.86	1243	4.45	1.01			
Pros	1573	1.42	0.55	1443	1.43	0.66	1243	1.43	0.74			
Cons	1573	4.58	0.65	1443	4.59	0.69	1243	4.54	0.82			
Situational Temptations	1573	1.17	2.64	1443	1.20	0.59	1243	1.23	0.67			
Smoking Acquisition Stages	1573	0.00	0.00	1465	1.04	0.26	1270	1.13	0.48	1158	1.16	0.52
Acquisition Precontemplation (aPC)	1573			1423 (97.1%)			1172 (92.3%)			1049 (90.6%)		
Acquisition Contemplation (aC)	0			22 (1.5%)			26 (2%)			30 (2.6%)		
Acquisition Preparation (aPR) and Smoking	0			20 (1.4%)			72 (5.7%)			79 (6.8%)		

Table 2.3. Single mediator model fit statistics with Pros, Cons, and Temptations as Mediators

Model	Chi square	df	CFI	RMSEA	SRMR
Pros as Mediator					
Consciousness Raising	389.04	83	0.959	0.048	0.063
Counter Conditioning	686.39	83	0.931	0.068	0.094
Dramatic Relief	352.79	83	0.965	0.045	0.057
Environmental Reevaluation	483.67	83	0.946	0.055	0.065
Helping Relationships	393.84	83	0.959	0.049	0.065
Refusal Assertiveness	549.46	83	0.966	0.052	0.058
Reinforcement Management	293.98	83	0.976	0.04	0.05
Self-Liberation	524.33	83	0.947	0.058	0.063
Self-Reevaluation	504.95	83	0.963	0.057	0.075
Social Liberation	520.07	83	0.943	0.058	0.063
Stimulus Control	428.48	83	0.956	0.051	0.07
Cons as Mediator					
Consciousness Raising	417.23	83	0.953	0.051	0.063
Counter Conditioning	720.70	83	0.927	0.07	0.097
Dramatic Relief	361.42	83	0.962	0.046	0.057
Environmental Reevaluation	467.80	83	0.946	0.054	0.066
Helping Relationships	421.97	83	0.953	0.051	0.064
Refusal Assertiveness	515.86	83	0.937	0.058	0.161
Reinforcement Management	294.56	83	0.974	0.04	0.049
Self-Liberation	537.37	83	0.944	0.059	0.062
Self-Reevaluation	509.31	83	0.962	0.057	0.075
Social Liberation	508.02	83	0.942	0.057	0.064
Stimulus Control	488.23	83	0.946	0.056	0.073
Temptations as Mediator					
Consciousness Raising	408.18	83	0.959	0.05	0.059
Counter Conditioning	647.78	83	0.939	0.066	0.085
Dramatic Relief	373.49	83	0.964	0.047	0.056
Environmental Reevaluation	465.66	83	0.951	0.054	0.064
Helping Relationships	393.76	83	0.961	0.049	0.062
Refusal Assertiveness	493.91	83	0.946	0.056	0.129
Reinforcement Management	294.56	83	0.974	0.04	0.049
Self-Liberation	537.37	83	0.944	0.059	0.062
Self-Reevaluation	509.31	83	0.962	0.057	0.075
Social Liberation	508.02	83	0.942	0.057	0.064
Stimulus Control	488.23	83	0.946	0.056	0.073

Table 2.4. Unstandardized (with standard errors) longitudinal regression paths describing the mediation pathway; Processes of change at Time 1 and Time 2 to mediator at Time 2 (a_1) and Time 3 (a_3); the mediator at Time 2 to smoking outcome at Time 3 (b_3) and mediator at time 3 to smoking outcome at Time 4 (b_5).

Model	a_1	s.e.	a_3	s.e.	b_3	s.e.	b_5	s.e.
Pros as Mediator								
Consciousness Raising	0.328	0.283	-0.397	0.366	0.005	0.007	.027*	0.007
Counter Conditioning	-0.104	0.307	-0.037	0.385	0.004	0.007	.026*	0.007
Dramatic Relief	0.421	0.248	0.003	0.311	0.006	0.007	.028*	0.007
Environmental Reevaluation	0.193	0.228	-0.305	0.27	0.004	0.007	0.027*	0.007
Helping Relationships	0.058	0.194	0.167	0.228	0.004	0.007	.028*	0.007
Refusal Assertiveness	-0.024	0.05	-0.051	0.072	0.006	0.007	.025*	0.007
Reinforcement Management	0.102	0.174	-0.048	0.172	0.008	0.007	.028*	0.007
Self-Liberation	-0.063	0.289	-0.427	0.312	0.002	0.007	0.026*	0.007
Self-Reevaluation	0.026	0.229	-0.212	0.256	0.002	0.007	0.026*	0.007
Social Liberation	0.294	0.307	0.134	0.361	0.001	0.007	0.027*	0.007
Stimulus Control	0.112	0.276	-0.178	0.26	-0.001	0.007	.025*	0.007
Cons as Mediator								
Consciousness Raising	0.064	0.323	-0.591	0.391	-0.004	0.006	-0.005	0.006
Counter Conditioning	0.554	0.307	-0.154	0.521	-0.005	0.006	-0.004	0.006
Dramatic Relief	0.019	0.307	-0.218	0.331	-0.007	0.006	-0.006	0.006
Environmental Reevaluation	0.264	0.271	-0.657	0.3	-0.004	0.006	-0.005	0.006
Helping Relationships	0.126	0.217	-0.508	0.266	-0.006	0.005	-0.007	0.006
Refusal Assertiveness	0.158	0.06	-0.026	0.079	-0.007	0.006	-0.005	0.006
Reinforcement Management	-0.197	0.187	-0.577*	0.216	-0.009	0.006	-0.007	0.006
Self-Liberation	0.433	0.323	-0.864	0.402	-0.002	0.006	-0.004	0.006
Self-Reevaluation	0.256	0.259	-0.644*	0.307	-0.003	0.006	-0.004	0.006
Social Liberation	0.15	0.337	-1.491*	0.475	-0.003	0.006	-0.005	0.006
Stimulus Control	0.19	0.29	-.656*	0.336	-0.001	0.006	-0.004	0.006
Temptations as Mediator								
Consciousness Raising	-0.296	0.438	-0.685	0.461	-0.004	0.007	.032*	0.008
Counter Conditioning	-0.645	0.514	-0.262	0.567	-0.004	0.007	.033*	0.008
Dramatic Relief	-0.108	0.364	-0.611*	0.34	-0.002	0.007	.033*	0.008
Environmental Reevaluation	-0.297	0.365	-0.532	0.318	-0.004	0.007	.032*	0.008
Helping Relationships	-0.128	0.282	-0.166	0.294	-0.004	0.007	.033*	0.008

Refusal Assertiveness	-0.129	0.096	-0.149	0.098	-0.003	0.007	.029*	0.008
Reinforcement Management	0.013	0.236	-0.084	0.193	-0.002	0.007	.033*	0.008
Self-Liberation	-0.592	0.466	-.929*	0.444	-0.006	0.007	.031*	0.008
Self-Reevaluation	-0.333	0.351	-0.537	0.339	-0.006	0.007	.032*	0.008
Social Liberation	0.007	0.438	-0.046	0.416	-0.007	0.007	.032*	0.008
Stimulus Control	-0.401	0.427	-.677*	0.334	-0.007	0.007	0.031*	0.008

Note: a1, and a2 are the indirect effects between the IV and mediator; b2 and b3 are the indirect effects between the mediator and smoking acquisition. * $p < .05$

Table 2.5. Unstandardized and standardized products, standard errors, and 90% Confidence Intervals for the processes of change that demonstrated statistical significance

Process Variable	Product of a_3 and b_5	s.e.	90% C.I.		Product of std. a_3 and b_5	s.e.	90% C.I.	
			LL	UL			LL	UL
Mediator: Situational Temptations								
Dramatic Relief	-0.02	0.012	-0.044	-0.005	-0.033	0.02	-0.066	-0.001
Self-Liberation	-0.029	0.016	-0.058	-0.008	-0.041	0.022	-0.077	-0.005
Stimulus Control	-0.021	0.012	-0.044	-0.004	-0.036	0.02	-0.069	-0.003

Figures

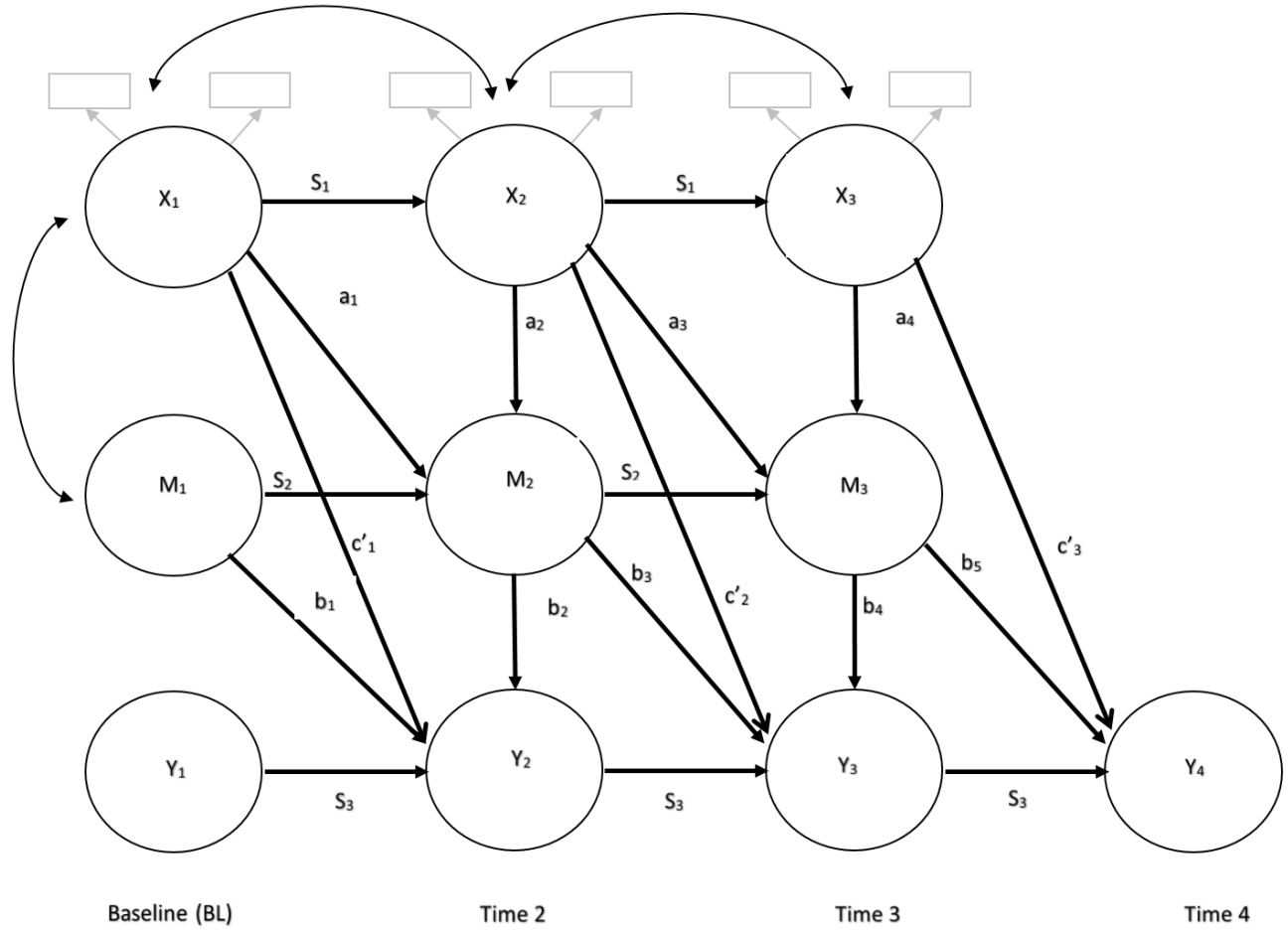


Figure 2.1. Template of Autoregressive II mediation model

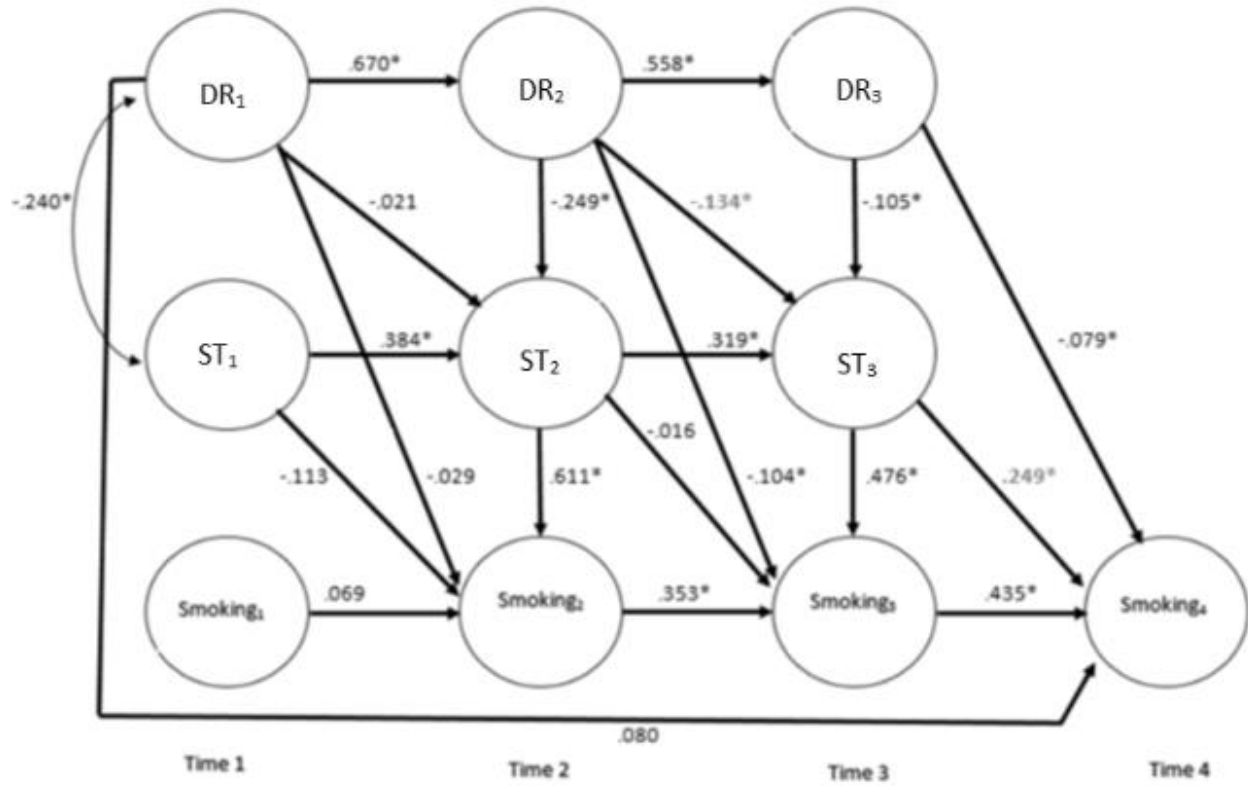


Figure 2.2 AR II Model: Dramatic Relief with Situational Temptations as the mediator

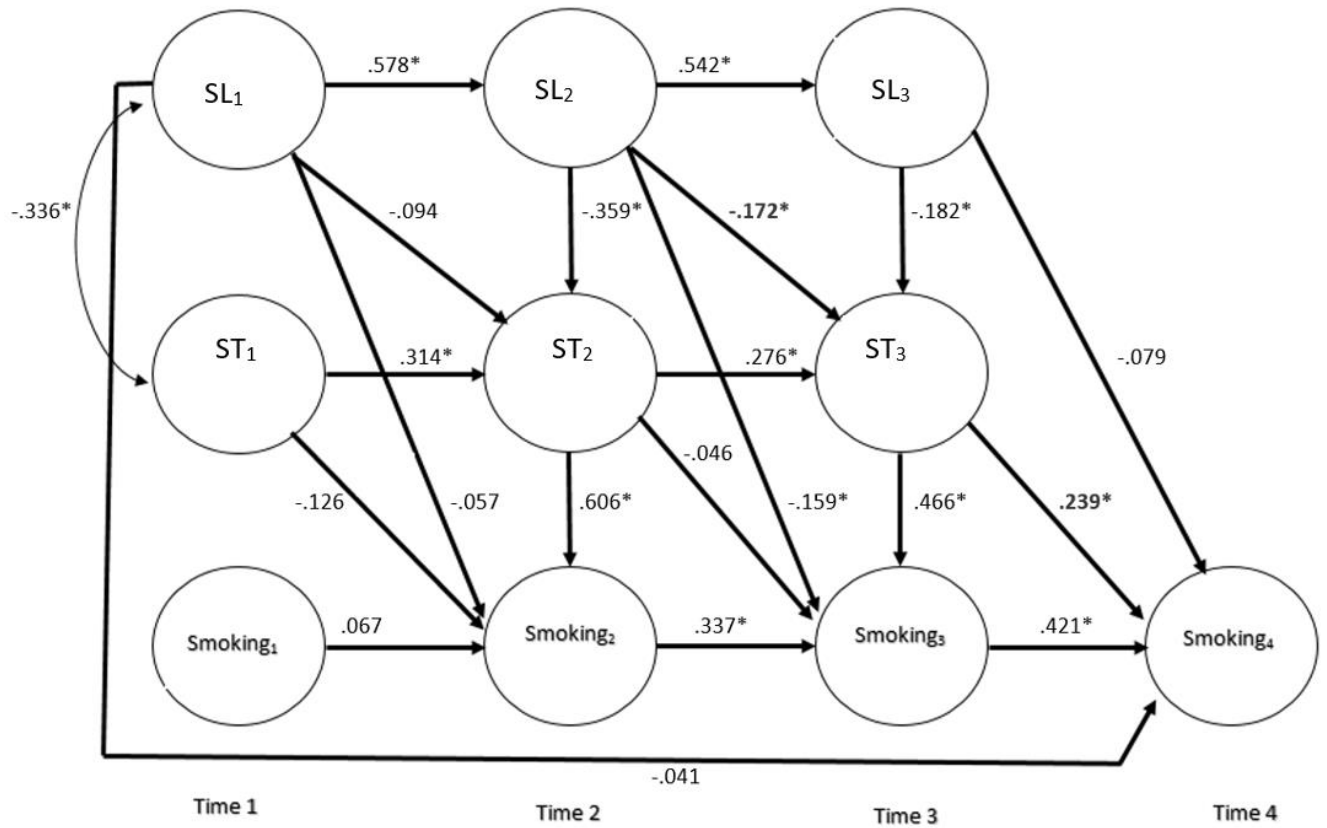


Figure 2.3. AR II Model: Self-Liberation with Situational Temptations as the mediator

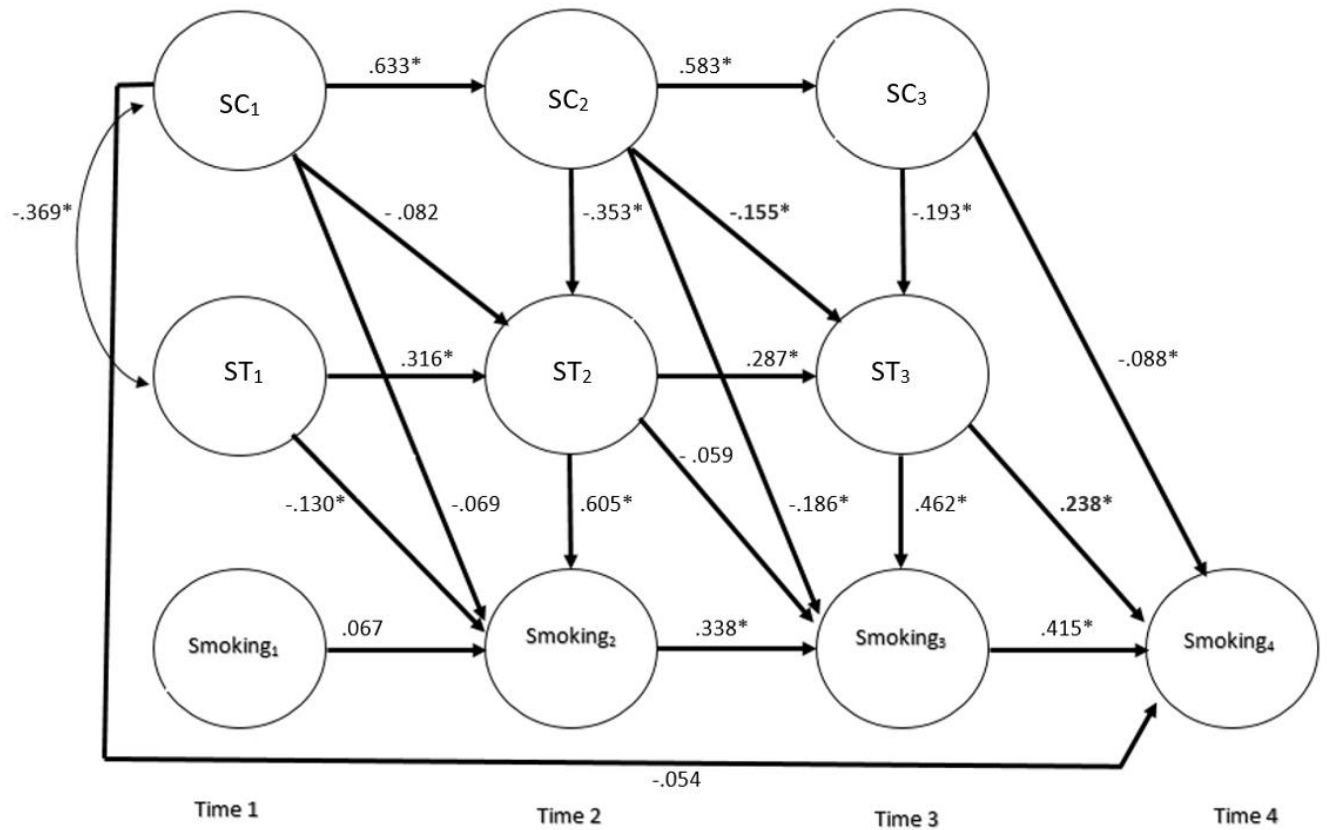


Figure 2.4 AR II Model: Stimulus Control with Situational Temptations as the mediator

Chapter 3

**“Testing for Moderation in Longitudinal Mediation Models of Smoking
Acquisition: Factorial Invariance Across Subgroups”**

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Abstract

Considerable efforts have been made to reduce the high prevalence of smoking in adults, while preventing young people from attempting to use cigarettes. However, the prevalence of current smoking among adolescents is still very high. Past research on youth smoking has largely focused on identifying important factors and correlates of smoking during adolescence (Hwang et al., 2004; Rose et al., 2012; Spoth et al., 2016), however no studies have examined causal pathways of smoking acquisition. Investigating and comparing causal mechanisms of youth smoking will help researchers better understand the most important factors of smoking acquisition during adolescence. Prior research identified causal relationships between Temptations and three Processes of smoking prevention: Dramatic Relief, Self- Liberation and Stimulus Control. The purpose of this study was to investigate gender and race as potential moderators in separate single-mediator models of Dramatic Relief, Self- Liberation, and Stimulus Control. Factorial invariance tests were utilized to evaluate the models for evidence of group differences due to gender or race (moderated-mediation). There was no evidence of moderated-mediation in any of the models that converged. Models of Dramatic Relief and Stimulus Control fit subgroups of gender and race well. However, models with Self-Liberation did not converge, and therefore, could not be evaluated for group differences. The results from this study facilitate a better understanding of the causal mechanisms that influenced smoking prevention behavior change during a critical period of adolescence.

Keywords: Statistical Mediation Analysis; Smoking acquisition; Smoking onset;
Transtheoretical Model; Acquisition Stages of Change

**Testing for moderation of longitudinal mediation in single mediator models:
Factorial Invariance across subgroups**

Tobacco use represents the largest preventable cause of disease and death in the United States (U.S. Department of Health and Human Services [USDHHS], 2010). Smoking during the middle school and high school years are of particular concern because it has been linked to numerous negative health outcomes, including increased risks of lung cancer and heart disease. In recent years, studies have shown cigarette use among middle and high school students has declined (Centers for Disease Control [CDC], 2017). Approximately 2.2% of middle school students reported smoking cigarettes in the past 30 days—a decrease from 4.3% in 2011, and 8% of high school students reported smoking—a decrease from 15.8% in 2011. Despite the huge reductions in smoking rates, more than 3,200 youth aged 18 years or younger smoke their first cigarette each day, and an additional 2,100 youth and young adults become daily cigarette smokers (USDHHS, 2014).

Past research on the etiology of youth smoking has identified a plethora of personal, social, and psychological factors and correlates of smoking (Leventhal and Cleary, 1980; Pallonen, et al., 1998; Plummer et al., 2001). As adolescence is established as a key period for initiating smoking, there is a clear need for primary prevention programs to target adolescents (Hwang, Yeagley, & Petosa, 2004). Despite the success of substance use prevention programs leading to reduced rates of tobacco use (Conrad, Flay & Hill, 1992; Hollis et al., 2005; Pentz, et al., 1989; Skara & Sussman, 2003). However, since the causes of smoking acquisition are numerous and involve complex interplay of many factors, for interventions to be successful, they

need to be informed by empirical research that can identify the most salient predictors of smoking acquisition.

A large number of longitudinal randomized and quasi-experimental substance use prevention studies have been conducted in schools and community-wide programs across the country since the early 1990's (Conrad, Flay & Hill, 1992; Pentz, et al., 1989). While some studies specifically examined smoking in select groups of students based on demographic characteristics, other researchers relied on more sophisticated methods, such as statistical mediation to examine the indirect effects of different various psychosocial variables (e.g. social norms, beliefs about smoking, temptations to smoke) on treatment outcomes. For example, one study found social norms among friends and beliefs about the benefits of drug use significantly mediated program effects that were designed to target alcohol, cigarette, and marijuana use (MacKinnon et al., 1991). The authors also found alcohol-use intentions were partially mediated by social norms and beliefs about the benefits of alcohol; however, perceived resistance skills, peer norms, and negative consequences of drug use did not mediate intentions. Another study found normative beliefs, lifestyle incongruence, and manifest commitment to not use drugs were mediated smoking outcomes, although, the effects were different across treatment methods (McNeal et al. 2004). The authors indicated that the program was only successful when it was delivered by teachers, whereas the program failed to have an effect on the mediators when the treatment was delivered by specialists. A study by Botvin et al. (1995) provided students with Life Skills Training (LST) and social-influences programs that were designed to teach general life skills and competence that could be used in situations involving peer pressure to smoke,

drink or use drugs. They discovered normative expectations and knowledge of smoking mediated the impact of the LST intervention effects on cigarette smoking. Moreover, no intervention effects were found for other cognitive factors such as self-efficacy, self-esteem, decision-making, and psychological wellbeing.

Taken together, these studies suggest that there are many psychosocial mechanisms that can mediate the uptake of smoking during adolescence. It is well established that there are important group differences in smoking. A recent study identified latent subgroups of adolescents that had the highest risks of tobacco use (Rose, Lee, Dierker, Selya, & Mermelstein, 2012). However, the most salient risk factors for smoking uptake have been demographic characteristics, such as age, gender, race/ethnicity and religion (Conrad et al., 1992). Other studies of smoking acquisition have also found boredom, negative affect, and social situations to be predictors of smoking uptake (Huang, et al., 2005; Plummer et al., 2001; Velicer et al., 2007).

The implications of these studies are that smoking has a complex ontogeny and the uptake of smoking during adolescence can be influenced by numerous demographic and psychological factors. Longitudinal designs and sophisticated research methods that can concomitantly evaluate and investigate moderators and mediators of smoking can help increase our understanding of the causal pathways among many factors and correlates of smoking acquisition. The following section introduces a theoretical framework for understanding important mechanisms of smoking acquisition.

One theory that is capable of elucidating causal pathways of smoking acquisition is the Transtheoretical model (TTM). The TTM is an integrative model

that comprises some of the most salient constructs and predictors of health behavior change (Hall & Rossi, 2008; Hoepfner et al., 2006; Pallonen et al., 1998; Plumber et al., 2001; Prochaska & Velicer, 1997; Velicer & Prochaska, 2000). The TTM has several core constructs including the acquisition stages of change (aSOC), processes of change, decisional balance, and temptations. The aSOC includes three stages of change that describes student's intentions to try smoking. The acquisition precontemplation (aPC) stage consists of those who have never smoked and have no intentions to do so in the next six months. The acquisition contemplation (aC) stage consists of never smokers who were thinking about trying smoking within the next six months. The acquisition preparation (aP) stage consists of never smokers who were thinking about trying smoking in the next 30 days. The acquisition stages have been used to highlight some of the most important psychological constructs and mediators of smoking acquisition during adolescence (Pallonen et al., 1998).

The processes of change for smoking prevention have a correlated higher-order factor structure representing two broad dimensions of change, *Experiential* and *Behavioral* (Krebs et al., 2006). Experiential processes include, Consciousness Raising, Dramatic Relief, Environmental Reevaluation, Self-reevaluation, and Social Liberation. Behavioral processes include, Stimulus Control, Counter Conditioning, Reinforcement Management, Self-Liberation, and Helping Relationships. The processes for smoking prevention include an 11th subscale called Refusal Assertiveness reflecting individual's ability to refuse offers from other people to try smoking. Refusal Assertiveness falls into the behavioral domain (Krebs et al., 2006).

Decisional balance and Temptations are key intermediate/outcome measures (aka mediators) that are theoretically causally proximal or intermediate to smoking and other behavior change outcomes (Huang et al 2005; Plummer et al., 2001; Prochaska & DiClemente, 1983; Prochaska, DiClemente, & Norcross, 1992; Prochaska & Velicer, 1997). A mediator is a third variable that explains the relationship between an independent and dependent variable. The decisional balance measures are the Pros and Cons of smoking prevention (Plummer et al., 2001). Some Pros would be the social benefits of smoking, such as fitting in, increased popularity and so on. An example of a con would be the perceived health risk associated with smoking. Adolescents who were not thinking about trying smoking (aPC stage), were likely to value the Cons more than the Pros of smoking (Pallonen, 1998). Temptations reflect situation-specific urges to try smoking across situations (McGee et al., 2012).

Statistical Mediation Analysis

Mediation analysis is a sophisticated statistical method used to demonstrate the causal sequence of effects, relating the effects of an independent variable (X), to the dependent variable (Y), through a mediating, or intervening variable (M). The relationship between X and Y thru M is said to be an indirect effect. That is, instead of X causing Y directly, X is causing M, and M is in turn causing Y (Baron & Kenny, 1986; MacKinnon, 2008).

Due to the inherent complexity of relations among behavioral variables, statistical mediation models with multiple mediators, multiple independent variables, or multiple dependent variables, almost always represent a more accurate and valid representation of statistical mediation (Hayes, 2013; MacKinnon, 2008; Preacher et

al., 2007). Demographic variables, such as age, gender, race/ethnicity, and education level are variables that may potentially moderate the a and/or b paths in a mediation model. Testing for the influence of moderation provides valuable insight about the validity, consistency and generalizability of the statistical mediation models (Hayes, 2013; Fairchild & MacKinnon, 2009; Wu & Zumbro, 2008).

Moderated-Mediation

As previously discussed, a mediator implies a situation where the effect of the independent variable on the dependent variable can be best explained via the mediator. A moderator, on the other hand, is a variable that changes the magnitude of the relationship between an independent and dependent variable. The presence of a moderator implies an interaction effect with an independent variable that changes the direction or magnitude of the relationship between other variables. In the context of mediation, a moderated-mediation occurs when either the relationship between the independent variable and the mediator (a path) or the relationship between the mediator and outcome (b path) varies according to the moderator (Baron & Kenny, 1986; MacKinnon, 2008).

Moderated-mediation has been used in the context of smoking cessation. Babbin (2014) examined several moderators of smoking cessation and found models with gender and race as moderators were invariant across different levels of the subgroups. The models used in the present study were informed by prior research that utilized mediation models to investigate several processes of change and mediators of smoking prevention. Figure 3.1 provides the path model of a four-way AR II model. The model illustrates the longitudinal relations between variables just one lag apart

(Cole & Maxwell, 2007; Gallob & Reichardt, 1991, MacKinnon, 2008). The AR II model assumes the values of a variable in the future depend on the values from previous time points and considers longitudinal stability in the model with stability measures for the same variable across time (e.g. S_1, S_2, S_3). The longitudinal direct effects between adjacent waves are the c' paths (E.g. X_1 to Y_2 and X_2 to Y_3). The mediational pathways in the figure show both contemporaneous and longitudinal relationships between X and M, the a_k paths (k represents the path at different waves). The longitudinal mediated effects—the most important parameters—are the indirect effects at different waves (e.g. a_1b_3 , reflects the first lag mediated effect, and a_3b_5 , in the second lag). The contemporaneous relations between variables imply that various temporal relations between the IV, mediator, and DV could exhibit convincing evidence of partial mediation (see MacKinnon, 2008). However, these paths were not explored because the goal of this study was to specifically evaluate the statistical significance of the longitudinal mediation pathways.

Purpose of this study

The purpose of this study was to investigate moderated mediation in 3 different single-mediator models that showed evidence of statistical mediation in Paper 2. The secondary aims were combined here for several reasons. First, only three processes showed evidence of statistical mediation via Temptations in Paper 2. Therefore, no multiple mediator models were available to be investigated (research aim 2). Second, when two or more IVs were included in the model (research aim 3), the models did not fit the data well or failed to converge with estimates of the standard errors. Even after making adjustments to the models, the models were unable to be combined. Therefore,

the aim of the current study (Paper 3) was to evaluate moderated mediation in three separate mediation models using temptations. Factorial invariance techniques were used to provide evidence of moderated-mediation (Cheung & Rensvold, 2002) with a multiple-group analysis. Models that reach strict levels of invariance will determine whether the mediation models were equivalent across different subgroups of gender (male vs. females) and race (whites vs. nonwhites).

METHODOLOGY

Subjects

The secondary dataset is a subsample from Project Best, a school-based RCT study that was conducted between 2007-2011 (Velicer et al., 2013). Middle school students were recruited from 20 middle schools in Rhode Island. Participating schools were matched on available school-level data to form matched pairs of schools that were then randomized to each group. The study had two treatment arms with each group serving as the comparison group for the other. Ten middle schools received an energy balance (EB) intervention, and ten schools received the substance use prevention (SP) intervention. The baseline assessment session and the first intervention session were administered at the beginning of sixth grade (2007–2008), where students received three 30-min computerized TTM-tailored intervention sessions approximately 2 months apart during seventh grade (2008–2009), and the final intervention session occurring at the beginning of eighth grade (2009–2010). Students were assessed yearly between 6th grade and 9th grade. Consent and other human subject protocols were approved by the University of Rhode Island Institutional Review Board, and research was conducted per APA ethical guidelines. Additional details about the original study, including demographics, procedures, and outcomes for both treatment arms can be found elsewhere (Velicer et al., 2013).

Data from the SP intervention group was analyzed because the processes of change for smoking were only measured in the SP intervention group, which were vital to addressing the aims and objectives of this study. Accordingly, the following

sample description is of the SP group. Among the baseline sample of sixth graders ($N=1573$), the mean age was 11.25 ($SD=0.50$), 51% were male, 66.2% white, 15.2% mixed, 7.6% Hispanic, and 4.5% Black. An independent samples t-tests revealed there were some significant gender differences on the total scores for many of the study variables, with girls reporting slightly higher mean scores compared to boys at baseline (see Table 3.1).

Measures

Acquisition Stages of Change. Participants who reported that they were not thinking of trying smoking/ in the next 6 months were classified into the Acquisition Precontemplation (aPC) stage (Velicer et al., 2007). In the present study, 100% of participants were aPC at baseline. At follow up evaluations, students were asked again about their intentions to try smoking and could have been classified into either aC (thinking about trying smoking in the next 6 months) or aPR (planning to try smoking in the next 30 days) or as smokers, if they had actually tried smoking.

Independent Variables

Processes of Prevention. The processes of change are conceptualized by latent variables identified with two or three items. Participants were asked to rate how often they used each Process in the last month on a 5-point Likert scale ranging from 1 (Never) to 5 (Repeatedly). The reliability and validity of the Processes of Prevention have been explored in previous studies (Krebs et al., 2006; Pallonen, 1998).

Mediators

Decisional Balance. Each scale includes multiple items for the pros and the cons of a behavior. The five items of the Pros scale measured advantages of smoking

(e.g. smoking makes kids get more respect from others, kids who smoke have more friends, kids who smoke go out on more dates). The five items of the cons scale assessed disadvantages of smoking (e.g. smoking stinks, smoking can affect the health of others, smoking cigarettes is hazardous to people's health). The items in the present study utilized a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Decisional Balance Inventory for Smoking Prevention has demonstrated sufficient factorial invariance and good reliability (Anatchkova et al., 2006; Plummer et al., 2001). Composite scores for the Pros and Cons subscales represented the latent variables in the mediation models.

Situational Temptations. The six-item Temptations to Try Smoking Scale consisted of two correlated subscales: Positive Social Situations and Curiosity about Smoking/Stress (three items for each scale). The Positive Social Situations scale (e.g. While talking to my friends, When I am having a good time) and Curiosity about Smoking/Stress scale (e.g. When I am stressed, When I want to know how a cigarette tastes) utilized a 5-point Likert scale ranging from 1 (not at all tempted) to 5 (strongly tempted). The scale has demonstrated sufficient factorial invariance (strong invariance) and good reliability (Anatchkova et al., 2006; McGee et al., 2012). A total composite score for the Temptations subscales was utilized in the mediation models.

Outcome Measure

Stages of Change for Smoking Acquisition. Students were asked if they were thinking about or planning to try smoking within the next 30 days (acquisition-preparation stage) or 6 months (acquisition-contemplation stage). Students who reported that they were not thinking of trying smoking in the next 6 months were

classified into the acquisition- precontemplation (aPC) stage. Smoking outcomes were measured on an ordinal 0-3 scale where each level was based on overall stage category at each time point. Only participants in the aPC stage at baseline were included in analyses, which resulted in a structural zero (0= structural 0, 1=aPC) for the baseline measure in the models. All subsequent time points modeled participants' movement to a higher stage of smoking acquisition (aC/aP=2, Smoker=3).

Statistical Analysis

An autoregressive mediation model (II) autoregressive mediation model was developed to assess mediation based from suggestions from Cole and Maxwell (2003) and MacKinnon (2008). There are six key characteristics to the autoregressive mediation model II (MacKinnon, 2008). First, relations are modeled one lag apart (e.g., Baseline to Time 2). Second, relations between the same variables over time are modeled to assess stability (the s coefficients). Third, the model includes regression paths that describe longitudinal mediation (e.g., independent variable at time 1 to mediator at time 2, independent variable at time 1 to dependent variable at time 2). Fourth, covariances among the variables at the first wave are estimated. Fifth, covariances among error terms are estimated at each wave. Sixth, relations between the independent variable and mediator, as well as mediator and dependent variable, are modeled. This is called contemporaneous mediation; the purpose of these paths was to help account for change that occurs between the time points. The template for the autoregressive mediation model II is included in Figure 3.1.

Missing Data

Although the retention of the baseline sample over each assessment point into the final wave of this study was high (76%), missingness could have been related to one or more covariates employed in the statistical model or to other unused variables available in the dataset, which would introduce bias into the models (Schafer & Graham, 2002). Therefore, Full Information Maximum Likelihood (FIML) was utilized in Mplus software to correct for any bias due to covariate dependent missingness that could have been related to the variables included in the model.

Assessment of Model Fit

Assessing the goodness of fit (GFI) was crucial to the validity of the mediation analyses in Study 1. Model fit refers to the ability of that particular model to reproduce the data (i.e., the variance-covariance matrix). The following GFIs were used to assess the model fit: Chi-square (χ^2), Comparative Fit Index (CFI), Root Mean Squared Error of Approximation (RMSEA), and the standard root mean squared residual (SRMR). Likelihood ratio chi-square provides a test for fit of the model based on the chi-squared distribution. The chi-square values were reported, but since their associated significance levels were nearly uniformly low due to large sample sizes (Kline, 2005), other means of evaluating models were explored. Due to this issue, a large chi-square value or significant p value (e.g. $<.05$) were not used in the decision making to either reject or retain the null model. The CFI statistic was used to indicate the relative improvement in the fit of the measurement model compared to a statistical baseline model. A value of .90 indicates good fit and estimates $\geq .95$ indicates excellent fit (Kline, 2005). The RMSEA is a parsimony-adjusted, absolute model fit index that accounts for the degrees of freedom in the model and sample size. Estimates below .10

indicates acceptable fit, $<.05$ indicates better fit and a value of zero indicates the best fit (Kline, 2005). The SRMR is an estimate of the standardized differences between the observed and the predicted covariances. SRMR residuals should be close to zero for a very close fit, but estimates below .08 indicate acceptable model fit (Kline, 2005). These statistics (e.g. CFI, RMSEA, and SRMR) were used to assess the extent to which the covariances predicted by the model corresponded to the observed covariances in the data. The mediation models that met model fit standards were retained.

The second phase of Paper 2 assessed the statistical significance of specific mediated effects (a_3b_5) to provide additional evidence of mediation. The follow up bias-corrected bootstrap procedure obtained the confidence limits, which were based on the distribution of the bootstrap mediated effect estimates (MacKinnon, 2008; Tofighi & MacKinnon, 2011). This bootstrap method is especially valuable for mediation models because of its accuracy for computing confidence intervals for the mediated effect and would provide evidence of statistical mediation if the 90% confidence interval (CI) did not include zero (MacKinnon, 2008).

The third step was to test the models for moderated-mediation. A multi-group SEM model approach treats the moderator as a group-level variable in order to compare the mediation effects in different subgroups simultaneously (Edwards and Lambert, 2007). This approach splits the sample into subgroups based on the moderator variable, and measurement invariance can be used to assess the presence of moderated mediation.

Measurement Invariance

Measurement invariance, sometimes referred to as factorial invariance, is a general term that can be applied to various components of a measurement model (Little et al., 2013). In general, measurement invariance involves testing the psychometric properties of measurement scales (Babbin et al., 2011; Harrington et al., 2011; McGee et al., 2012). In this context, measurement invariance is used to determine whether items used in survey-type instruments mean the same things to members of different groups (Cheung & Rensvold, 2002). Establishing measurement invariance is necessary for comparisons of means or regression coefficients across different populations or groups such as gender, culture, language spoken, and race. A multi-group confirmatory factor analysis (CFA) is a popular method for evaluating measurement invariance. In this context, measurement invariance is a test for moderation because the procedure identifies subgroups that do not fit a specified model. Various parameters in the model can be set equal or vary across groups and the model fit of the series of nested multiple group models, is used to assess the level of measurement equivalence. Several levels of measurement invariance, from the least to most restrictive level of invariance (Configural, Metric, Scalar, and Strict), were evaluated to observed whether changes in the constructs are true construct differences that were not due to measurement artifacts or item biases (Little, 2013). Based on the recommendations of Cheung and Rensvold (2002), a model was shown to be invariant if the ΔCFI and/or $\Delta RMSEA$ statistics did not exceed the > 0.01 threshold.

Levels of Invariance

Configural invariance tests whether the groups have the same factor structure by imposing no equality constraints in the model. This level of invariance is often used as the baseline model to which models that are more restrictive can be compared. The next level, Metric invariance (aka weak invariance), constrains the factor loadings to be equivalent across groups (i.e. zero loadings on the same constructs and unconstrained nonzero factor loadings). Metric invariance provides weak evidence as to whether the relationships between items and their underlying constructs are the same across groups. Scalar invariance (aka Strong invariance) constrains the item intercepts, and factor loadings to be equal, while allowing the factor means to vary across groups. Strong invariance indicates the factor loadings across groups are invariant. This level of invariance is considered a prerequisite for the comparison of latent means, because it implies that the measurement scales have the same operational definition across groups. Failure to reach this level of invariance means there is evidence of moderation. The final level is Strict Invariance. Strict invariance allows the factor means to vary, but places constraints on the item loadings, intercepts and error variances to be equal across groups. If for example, the ΔCFI and/or $\Delta RMSEA$ values were greater than .03 when comparing Strict to Scalar invariance, then there was evidence that group differences in the covariances and in the means in the manifest variables were attributable to group differences covariances and means on the latent variables. Since strict factorial invariance is very difficult to achieve, Scalar invariance was considered the appropriate benchmark to show that a model was

invariant. Failure to achieve scalar invariance indicates the presence of moderation, which could threaten the validity of the mediation results (MacKinnon, 2008).

Results

Creation and Fit Assessment of Mediation Models

In Study 1, creation of the single-mediator models was guided by the hypothesized TTM framework, where the independent variables (X) were the processes of change, the pros, cons and situational temptations of smoking were mediators (M), and stage was the smoking outcome (Y). In the present study, only three models of situational temptations showed evidence of longitudinal mediation. Mplus software was used to construct the models and investigate whether the proposed independent variables and mediators showed evidence of moderated-mediation. Basic descriptive statistics for the study variables at baseline (means and standard deviations) and mean gender differences are included in Table 3.1.

Model Fit Statistics. Models with Dramatic Relief, Self-Liberation and Stimulus Control as the IVs and temptations as the mediator, all demonstrated good fit, with CFI values consistently well above 0.90 and RMSEA values consistently below 0.08.

Assessing Statistical Mediation

Situational temptations mediated the relationship between smoking uptake over time and Dramatic Relief, Self-Liberation, and Stimulus Control in Study 1. The mediation pathways (process at Time 1 to mediator at Time 2, a_1 , mediator at Time 2 to the outcome at Time 3, b_3 ; and process at Time 2 to mediator at Time 3, a_3 , mediator at Time 3 to the outcome at Time 4, b_5) within each model was assessed in two steps. First, the statistical significance of each path (e.g. a_3 and b_5 in Figure 3.1) was assessed. Evidence of mediation was found only between a_3 and b_5 . These

processes, with unstandardized regression paths, were Dramatic Relief ($a_3 = -0.611$, $b_5 = 0.033$); Self-Liberation ($a_3 = -0.929$, $b_5 = 0.031$); and Stimulus Control ($a_3 = -0.677$, $b_5 = 0.031$). The results from the bias-corrected bootstrap procedure produced the asymmetric confidence intervals for the product of these paths (see Paper 2), provided additional evidence of statistical mediation. All three processes had confidence limits that did not include zero: Dramatic Relief (-0.066, -0.001; std. product = -0.033, small effect); Self Liberation (-0.077, -0.005; std. product = -0.041, small effect); and Stimulus Control (-0.069, -0.003; std. product = -0.036, small effect). The final three single-mediator models were assessed for moderation by testing across subgroups of gender and race. The hypothesis tests between the various models are found Table 3.2. Model 0 refers to the Configural level of invariance, Model 1 was used to reflect Metric invariance, Model 2 was Scalar invariance, and Model 3 was Strict invariance. Table 3.2 provides the testing results for the factorial invariance between different models.

Dramatic Relief

Gender

As Table 3.2 shows, the chi-square difference for gender Model 1 versus Model 0 ($\Delta\chi^2=15.36$, $df=6$, $p=.01$) was statistically significant. However, due to the large sample size ($N=1152$), the $\Delta\chi^2$ test may result in significant values even for trivial differences. Therefore, the $\Delta\chi^2$ values were reported, but not used to assess invariance. The ΔCFI in Model 1 was very small and not significantly different ($\Delta CFI=-0.002$) from model 0, and the RMSEA slightly improved ($\Delta RMSEA=-0.002$), thus providing evidence for weak invariance in the factor structure across the

two groups. The chi-square difference for Model 2 versus Model 1 ($\Delta\chi^2=52.46$, $df=6$; $p < .001$) was statistically significant. The ΔCFI in Model 2 was small and not significantly different ($\Delta CFI=-0.007$) from model 1, and the RMSEA slightly increased ($\Delta RMSEA= 0.002$), thus providing evidence for strong factorial invariance in the factor loadings and item intercepts. Further, the chi-square difference for Model 3 versus Model 2 ($\Delta\chi^2=581.75$, $df=16$; $\Delta CFI=-0.072$) was statistically significant at the 0.05 level, thus providing evidence for Scalar factorial invariance. The standardized path estimates for Males and Females are in Figures 3.2 and 3.3, respectively.

Race

As the results in Table 3.2 show, the chi-square difference for gender Model 1 versus Model 0 ($\Delta\chi^2=5.89$, $df=6$, $p = .44$) was not statistically significant. The ΔCFI in Model 1 did not change ($\Delta CFI=0$) from model 0, and the RMSEA slightly improved ($\Delta RMSEA= -0.001$), thus providing evidence for weak invariance in the factor structure across the two groups. The chi-square difference for Model 2 versus Model 1 ($\Delta\chi^2=9.78$, $df=6$; $p = .13$) was not statistically significant. The ΔCFI in Model 2 was small and not significantly different ($\Delta CFI=-0.001$) from model 1, and the RMSEA did not change ($\Delta RMSEA= 0.00$), thus providing evidence for strong factorial invariance in the factor loadings and item intercepts. Further, the chi-square difference for Model 3 versus Model 2 ($\Delta\chi^2=138.62$, $df=16$; $p < .001$) and significant $\Delta CFI=-0.015$, provided additional evidence for Scalar factorial invariance. The standardized path estimates for Whites and non-whites are in Figures 3.4 and 3.5, respectively.

Self-Liberation

Among the statistical mediation models that were tested with self-liberation, all of the models associated with levels of the grouping variables failed to converge. In all cases, modifying the convergence criterion, placing constraints on paths, or removing variables did not lead to convergence. Because of the challenges with getting these models to converge with estimates, invariance tests were not performed on Self-Liberation.

Stimulus Control

Gender

The chi-square difference for gender Model 1 versus Model 0 ($\Delta\chi^2=22.06$, $df=6$, $p=.001$) was statistically significant. The ΔCFI in Model 1 was very small and not significantly different ($\Delta CFI=-0.002$) from model 0, and the RMSEA did not change ($\Delta RMSEA=0.00$), thus providing evidence for weak invariance in the factor structure across the two groups. The chi-square difference for Model 2 versus Model 1 ($\Delta\chi^2=5.63$, $df=6$; $p=.47$) was not statistically significant. There was no change in CFI ($\Delta CFI=-0.007$) from model 1, and the RMSEA slightly improved ($\Delta RMSEA=-0.001$), thus providing evidence for strong factorial invariance in the factor loadings and item intercepts. Further, the chi-square difference for Model 3 versus Model 2 ($\Delta\chi^2=340.73$, $df=16$; $\Delta CFI=-0.039$) was statistically significant at the 0.05 level, thus providing evidence for Scalar factorial invariance. The standardized path estimates for Males and Females are in Figures 3.6 and 3.7, respectively.

Race (White vs Nonwhite)

Among the statistical mediation models that were tested with stimulus control, the Configural, and weak levels of invariance models associated with levels of the grouping variables for race failed to converge. In all cases, modifying the convergence criterion did not help the models converge. However, the models did converge when scalar and strict levels of invariance were tested. Since Configural level of invariance could not be established as the baseline model, the Scalar model was substituted as the baseline model. The chi-square difference for Model 3 versus Model 2 ($\Delta\chi^2=106.84$, $df=16$; $p<.001$) was statistically significant. The $\Delta CFI=-0.011$, $\Delta RMSEA=.003$, and $\Delta BIC= 308.41$, provided additional evidence for Scalar factorial invariance. The path estimates for White and non-White are in Figures 3.8 and 3.9 respectively.

Discussion

Factorial Invariance techniques were utilized to test for the presence of moderation in three separate single-mediator models of situational Temptations to try smoking. Gender and Race were investigated as potential moderators in each of the models (see Figures 3.2-3.9). Evidence of scalar factorial invariance was found across all models except for Self-Liberation, which failed to converge with reliable SEs. Additionally, models of stimulus control with race failed to converge at the lower levels of invariance, but did converge at the scalar and strict levels of invariance. These convergence errors may have been associated with very small estimates and large standard errors due to the very small sample sizes at some levels of the DV when the moderators were included in the analysis. It may also be due to the negative impact of omitting small theoretically insignificant factor loadings. By systematically testing the models with different parameters constrained, models for Self-Liberation could have converged. Notwithstanding, the models provided some evidence that models of smoking acquisition over 4 years were relatively similar for males compared to females and for whites compared to non-whites. These results are in line with other research (Fairchild & MacKinnon, 2009; Wu & Zumbo, 2008), however, future studies should consider testing these models with more varied and specialized subgroups (e.g. White Males vs Non-white females).

Patterns of Invariance

The invariance tests showed that the models fit well for all of the subgroups. However, further inspection of the path models revealed that the *a* and *b* paths that were significant without the moderators in the model, were no longer significant in the

more complex models that included gender or race. There was inconsistent evidence that the *a* paths (*a*3) between situational temptations at time 3 and Dramatic relief or Stimulus Control at time 2 were still significant. Except for a few instances, the *b* paths (*b*5) were no longer significant, suggesting a possible suppressing effect of the moderators on the mediational pathways, as shown by the 90% C.I. estimates for both models with gender and race including zero. These findings are in direct conflict with the results from the factorial invariance tests, which showed no evidence of moderation. To my knowledge, there have been no studies that discuss how or why the path estimates change even when there is no evidence of moderation. These findings were interesting given that multiple statistics that indicated the models fit well for both groups, yet the products of the indirect effects were no longer significant and the magnitudes of the path estimates became smaller or reversed sign in many of the models, after adjusting for the effects of the moderators. One possible explanation for our findings was that moderated-mediation could have occurred in paths that were not directly observed. Muller, Judd, & Yzerbyt (2005), described several ways moderated mediation could occur. For example, an independent variable could moderate the relationship between the mediator and the dependent variable (*b* path) or the relationship between the independent variable and the mediator (the *a* path). Moderated mediation could also occur when one moderating variable affects both the relationship between the independent variable and the mediator (the *a* path) and the relationship between the mediator and the dependent variable (the *b* path) at the same time. The present study observed the latter form of mediation, which means it is possible that the groups could have had small underlying differences in motivations to

try smoking on different paths that were not tested with the analytics that were used in this study.

Limitations

There were several practical and methodological limitations that prevented a more thorough examination of the study aims. The use of secondary data with missing data represents the biggest limitation to the present study in a number of ways. First, the current study data was limited to only the treatment group. Since there was no control group, the statistical mediation analyses were unable to test whether the intervention had any effect on smoking acquisition. A suitable control group may have allowed us to determine whether changes in smoking acquisition was moderated by intervention group status and would provide stronger evidence for causality.

Furthermore, given the lack of a control group and multiple missing measures, the analyses could not provide any insight regarding treatment effects on smoking or the processes of change. Second, the diversity of the sample was suboptimal. Although there was a reasonable distribution based on gender (51% male), nearly two-thirds of the sample was white, with the next highest category being mixed (15%). A more diverse sample, with more participants from different races and ethnicities, would greatly improve the generalizability of these findings.

Third, there were several limitations with the measures which impacted the ability of the models to converge. Hence, the pragmatic approach to building parsimonious models by removing some of the non-essential variables in the model. With so few students thinking about smoking or starting to smoke between 6th and 9th grades, there was no variation in the dependent variable at baseline and very little

variability thereafter, and was suspected as the cause of several convergence problems in models of Stimulus Control and Self-Liberation. Since the entire sample at baseline were non-smokers, this in effect led to a structural zero for the smoking DV at baseline. This may have caused the various problems with model convergence, which led us to believe that by removing several measures that were not evaluated in the longitudinal mediation hypotheses, the stability of the models would improve and the models would converge. However, the smoking DV at baseline actually improved statistical power and helped stabilize the models, leading to smaller standard errors in the models that did converge, which meant that the structural zero (or any other measures that were not viewed as critically important for testing longitudinal mediation) needed to be included in the model. Otherwise, the size of the standard errors for all of the parameters in the models would increase and that led to completely null findings (i.e. no statistical mediation). Although the AR II model successfully demonstrated longitudinal mediation in samples with adult smokers (Babbin, 2014; Babbin et al., 2017), the template in the present study may have been limited by the small sample of students' moving to higher stages of smoking acquisition. A study by Hoyle and Kenny (1999) simulated data sets with sample sizes of 25, 50, 100 and 200 and fit the data with models that included latent variables and observed variables and found sample sizes of less than 100 were more likely to have estimation problems. Since so few students moved to higher stages of change for trying smoking or started smoking at each time point, there were fewer observations and thus very limited variation to be estimated in these models.

Future Directions

Due to the inherent complexity of relationships among variables, statistical mediation models with multiple mediators, multiple independent variables, or multiple dependent variables almost always represent a more comprehensive and accurate representation of statistical mediation (Hayes, 2013; MacKinnon, 2008; Preacher et al., 2007). However, complex models featuring different combinations of IVs, mediators, and in some cases moderators, could not converge with reliable estimates, which points to various issues with the measures. In retrospect, four subsets of the sample dataset should have been created so that each group would be its own dataset (i.e. Male only dataset, Female only dataset, etc.). This could have improved the chances that the models would converge with good fit estimates. However, this approach has limitations too. For instance, splitting up the sample size affects some of the goodness of fit statistics (e.g. Chi-square, RMSEA). It also reduces overall statistical power because the models are now being estimated separately, which reduces power and inflates the chances of obtaining a Type I error.

Future research should also consider exploring the intersection of other demographic characteristics, such as socioeconomic status, residence (i.e. Rural vs Urban vs Suburban), and religion, may provide valuable insight about the validity, consistency and generalizability of these statistical mediation models.

Conclusions

This study found Temptations to try smoking to be an important mediator of smoking uptake over four years. Dramatic Relief, Stimulus Control and Self-Liberation were among the most important Processes of Prevention. This study

increases our basic knowledge of the psychological mechanisms that underlie smoking acquisition. These findings may lead to improvement and refinement of smoking prevention interventions.

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Tables

Table 3.1 Independent samples t-test results for males and females at baseline

Study variables at baseline	Male (N=791)		Female (N=760)		t value
	M	SD	M	SD	
Counter Conditioning	4.75	0.70	4.82	0.49	-2.30*
Consciousness Raising	4.36	0.93	4.51	0.72	-3.40***
Dramatic Relief	4.17	1.04	4.53	0.75	-7.66***
Environmental Reevaluation	4.23	1.00	4.30	0.91	-2.10***
Helping Relationships	4.28	0.92	4.38	0.78	-1.49
Refusal Assertiveness	4.45	0.85	4.53	0.69	-2.05*
Reinforcement Management	3.94	1.24	4.07	1.17	-2.09*
Stimulus Control	4.48	0.90	4.58	0.71	-2.45**
Self-Liberation	4.52	0.87	4.67	0.65	-3.79***
Social Liberation	4.44	0.88	4.52	0.69	-2.20*
Self-Reevaluation	4.64	0.82	4.78	0.57	-4.05***
Pros	7.11	2.76	6.95	2.71	1.10
Cons	22.74	3.40	23.16	2.92	-2.59**
Temptations	7.01	2.80	6.94	2.38	0.54

Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3.2 Model Fit statistics and nested model comparisons

Model	χ^2	DF	CFI	RMSEA	BIC	Hypothesis Test	$\Delta\chi^2$	Δdf	p value	ΔCFI	$\Delta RMSEA$	ΔBIC
Dramatic Relief												
Gender												
Configural	522.915	166	0.955	0.053	58458.172	n/a						
Metric	538.277	172	0.954	0.052	58429.455	Model 1-Model 0	15.36	6	0.01	-0.002	-0.002	-28.72
Scalar	590.739	178	0.948	0.055	58437.838	Model 2-Model 1	52.46	6	0	-0.007	0.002	8.38
Strict	1172.484	194	0.877	0.081	58902.036	Model 3-Model 2	581.75	16	0	-0.072	0.025	464.20
Race												
Configural	543.221	166	0.954	0.054	59164.378	n/a						
Metric	549.109	172	0.954	0.053	59126.193	Model 1-Model 0	5.89	6	0.44	0	-0.001	-38.18
Scalar	558.889	178	0.953	0.053	59091.901	Model 2-Model 1	9.78	6	0.13	-0.001	0	-34.29
Strict	697.509	194	0.938	0.058	59112.995	Model 3-Model 2	138.62	16	0	-0.015	0.005	21.09
Stimulus Control												
Gender												
Configural	579.143	166	0.951	0.057	56628.65	n/a						
Metric	601.208	172	0.949	0.057	56606.635	Model 1-Model 0	22.06	6	0.001	-0.002	0	-22.01
Scalar	606.842	178	0.949	0.056	56568.19	Model 2-Model 1	5.63	6	0.47	0	-0.001	-38.44
Strict	947.57	194	0.91	0.071	56791.371	Model 3-Model 2	340.73	16	0	-0.039	0.015	223.18
Race												
Configural	n/a	-	-	-	-	n/a						
Metric	n/a	-	-	-	-	-						
Scalar	585.071	178	0.951	0.054	56865.523	-						
Strict	713.677	194	0.938	0.059	56876.604	Model 3-Model 2	128.61	16	0	-0.013	0.005	11.08

Notes: Model 0= Configural Invariance; Model 1= Metric Invariance; Model 2= Scalar Invariance; Model 3= Strict Invariance

Figures

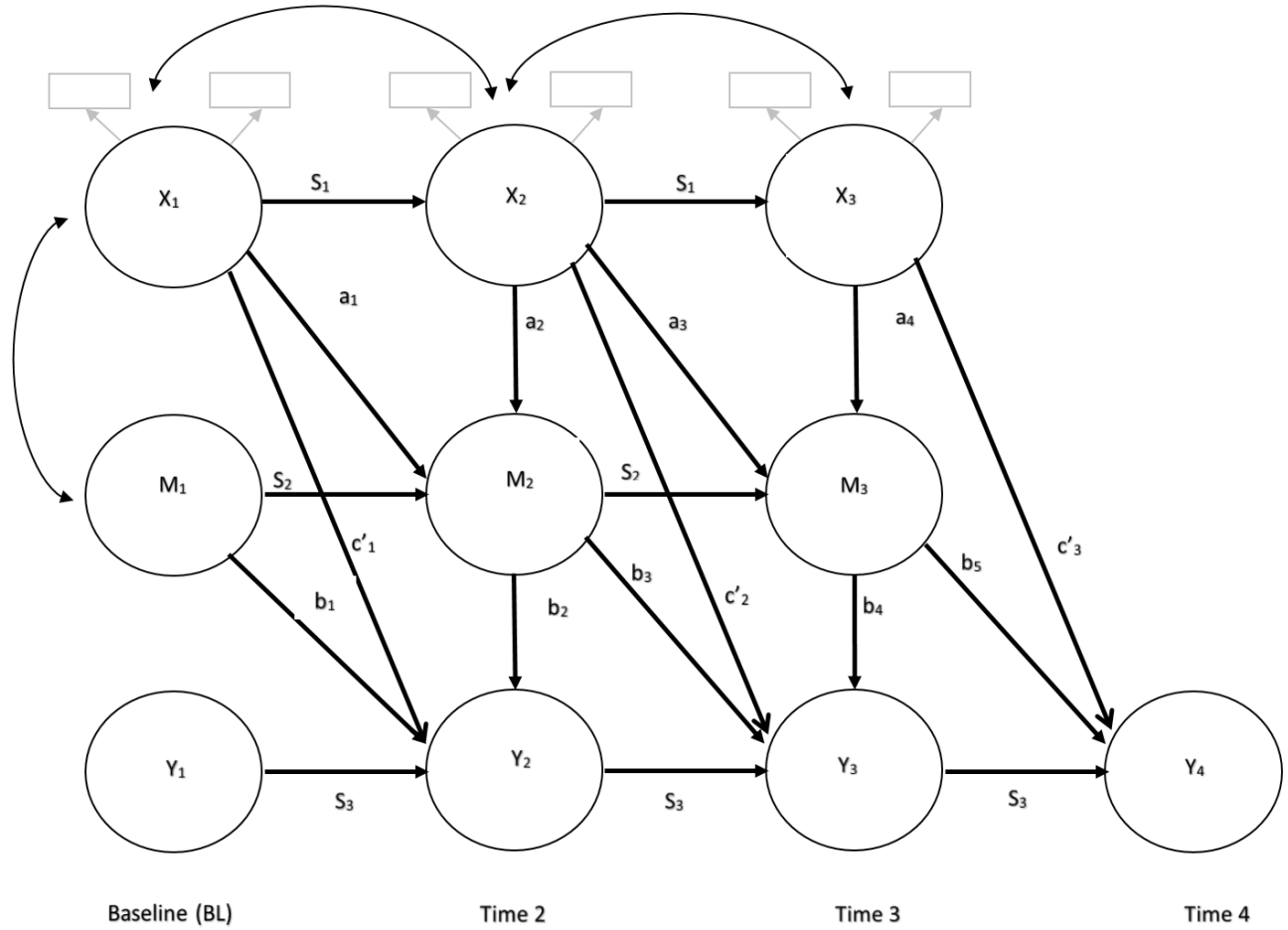


Figure 3.1. Template of Autoregressive II mediation model

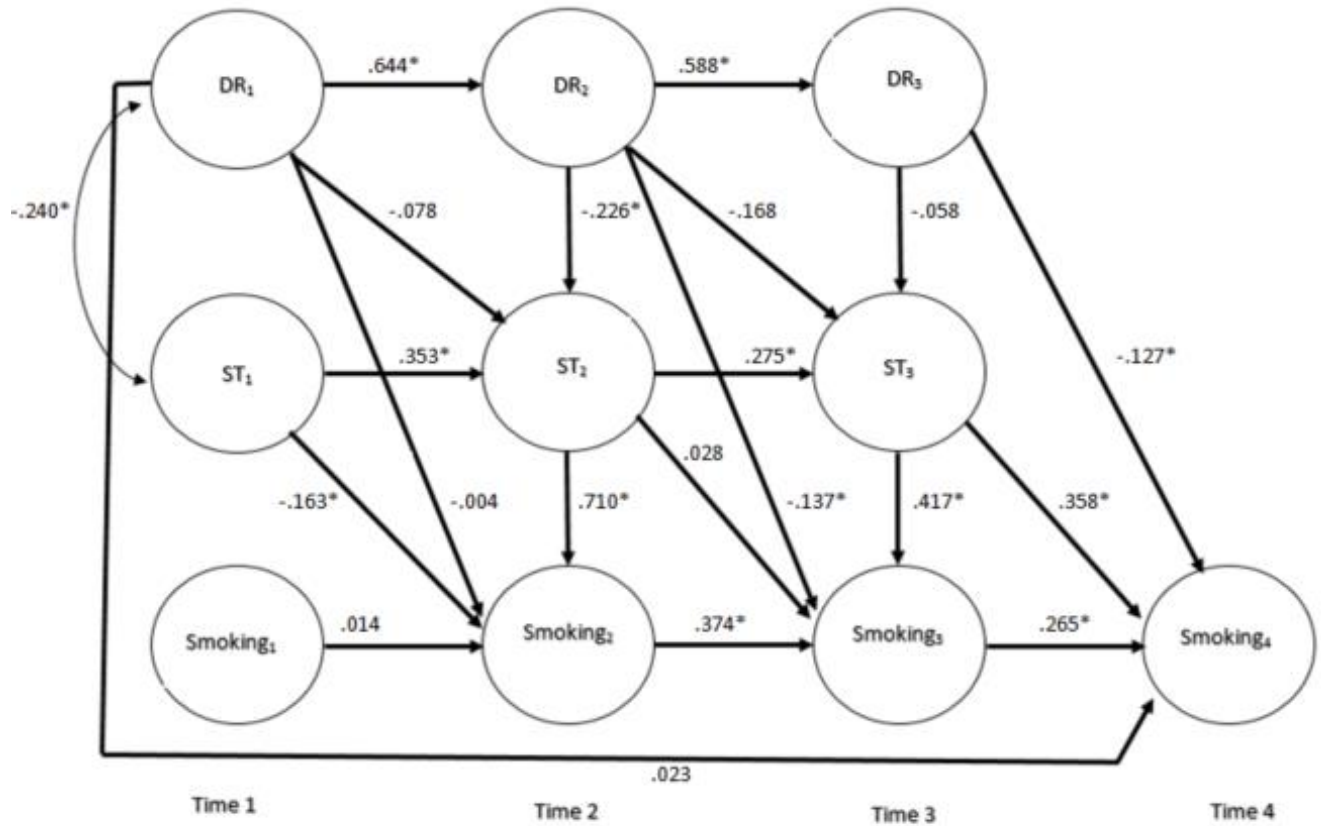


Figure 3.2 Situational Temptations Dramatic Relief (Males)

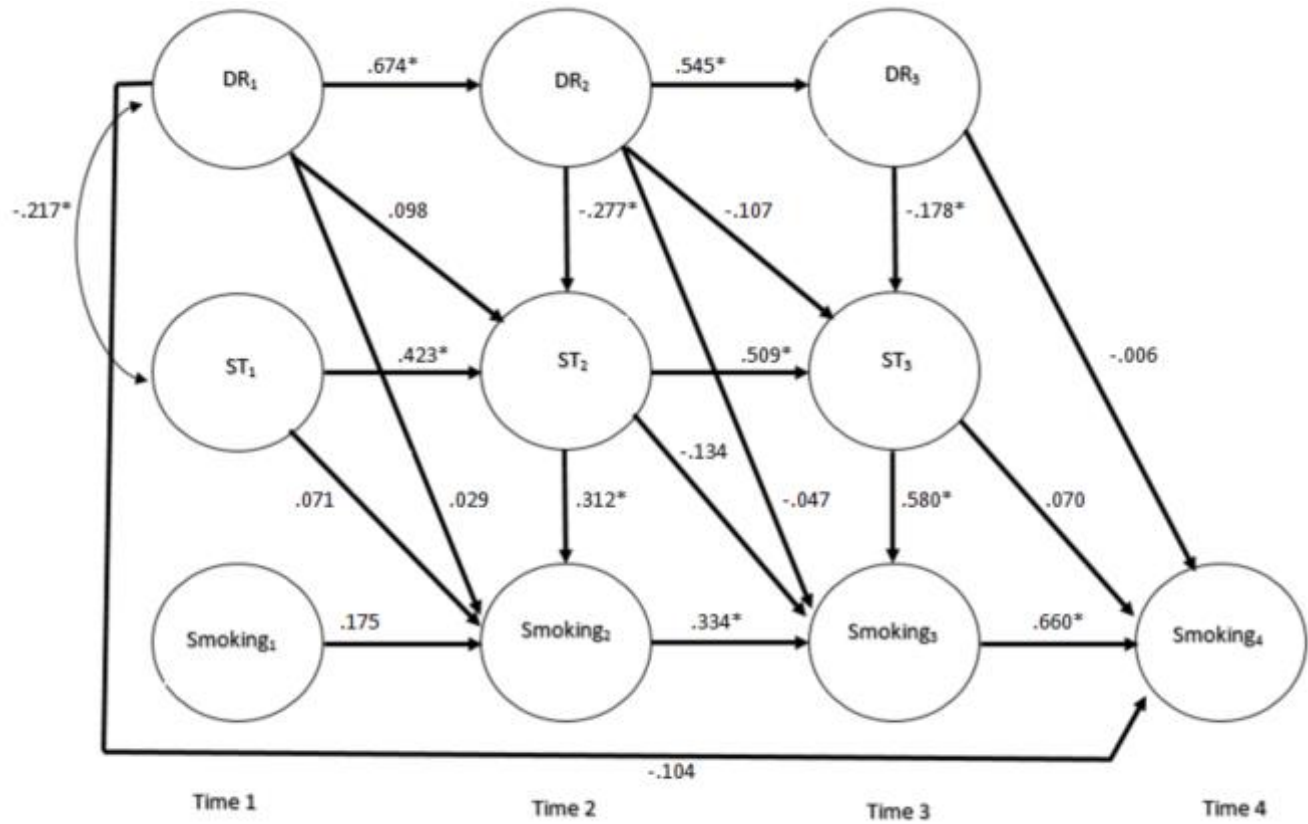


Figure 3.3 Situational Temptations Dramatic Relief (Females)

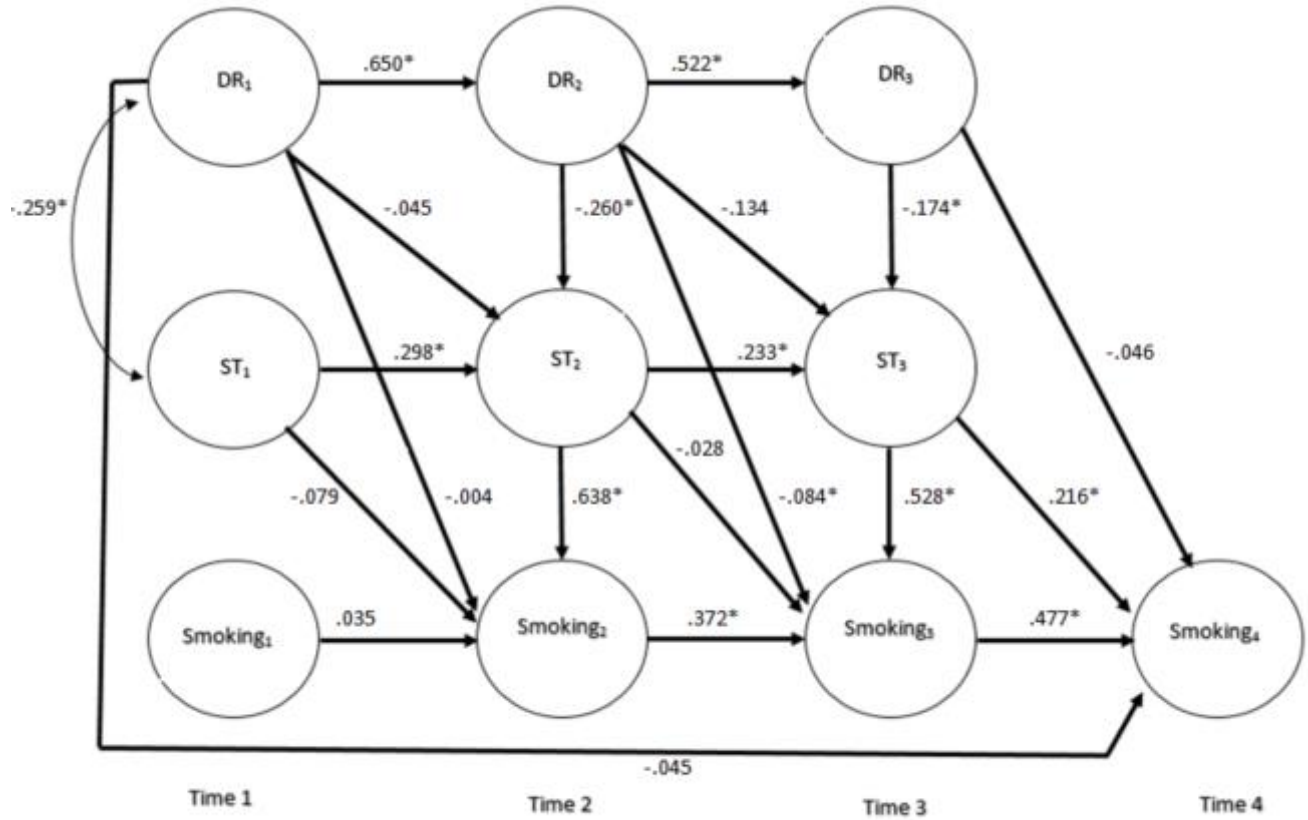


Figure 3.4 Situational Temptations Dramatic Relief (White)

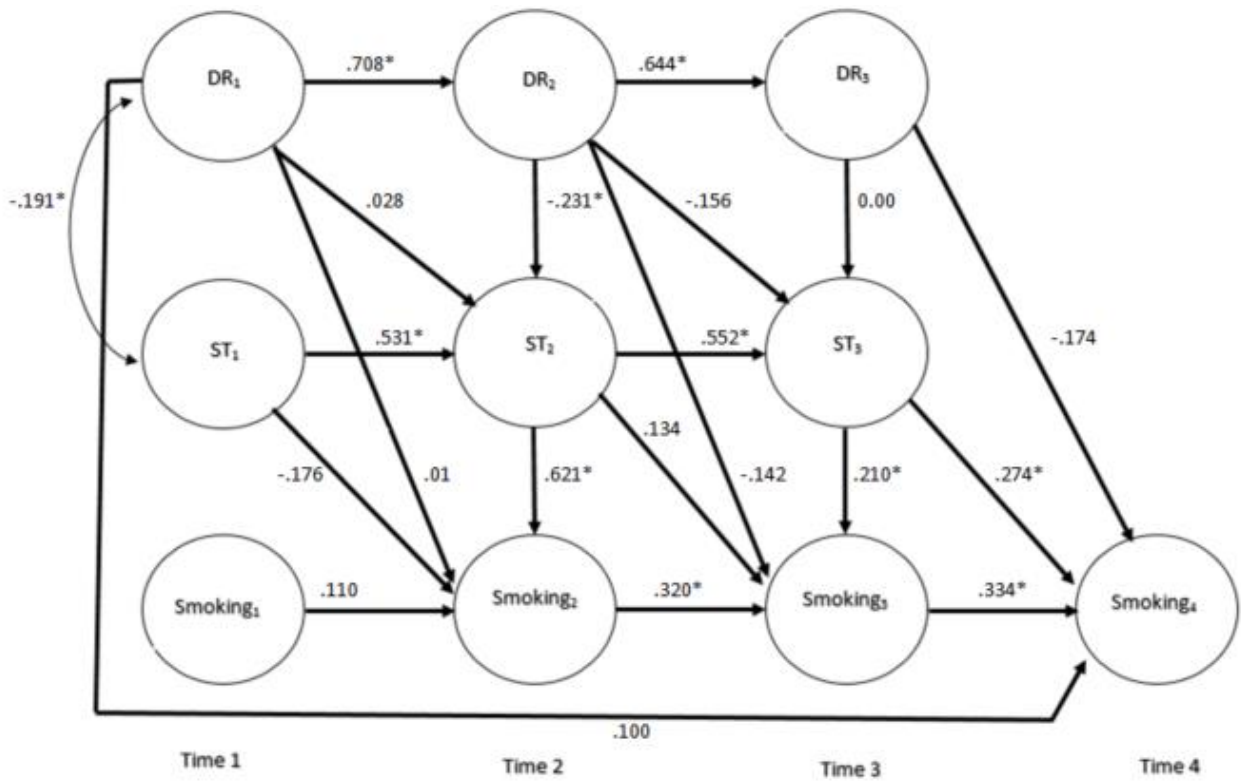


Figure 3.5 Situational Temptations Dramatic Relief (Non-White)

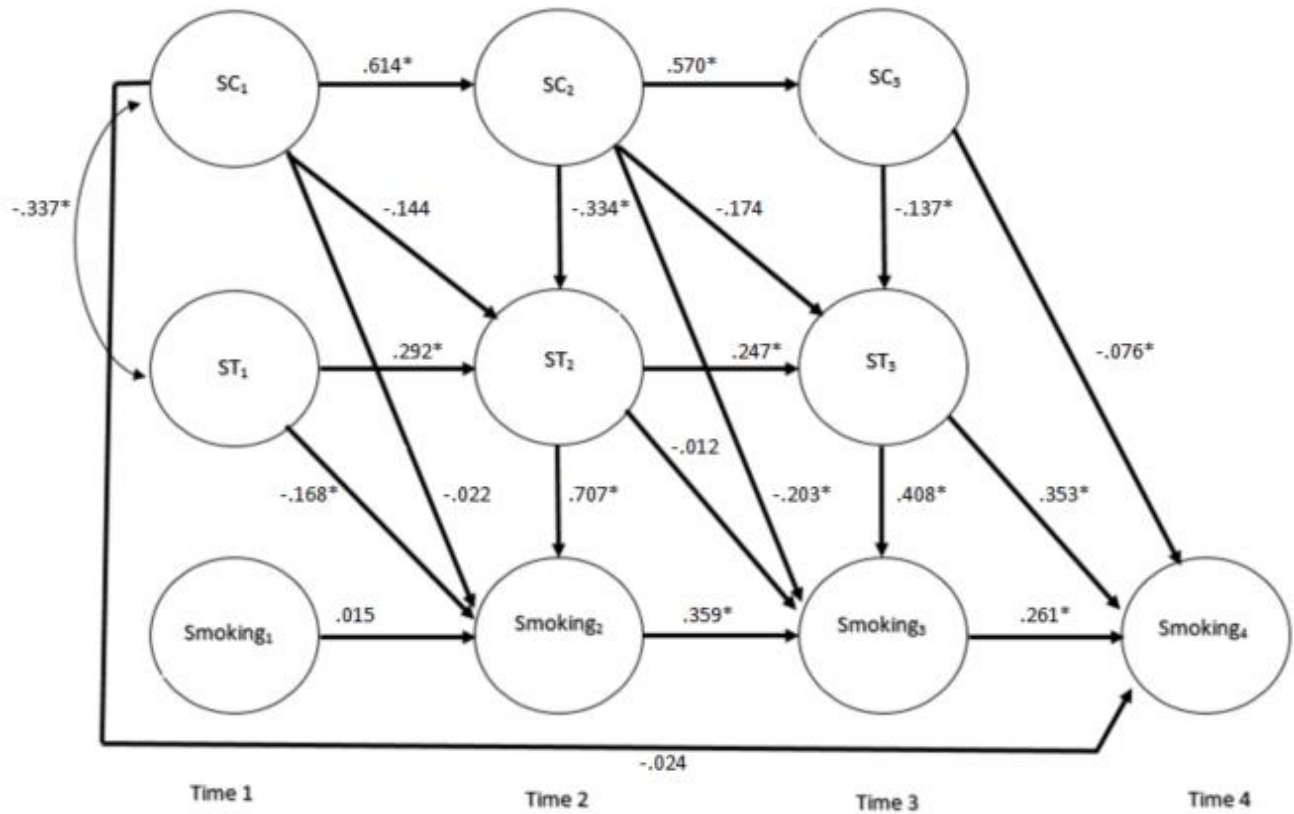


Figure 3.6 Situational Temptations Stimulus Control (Males)

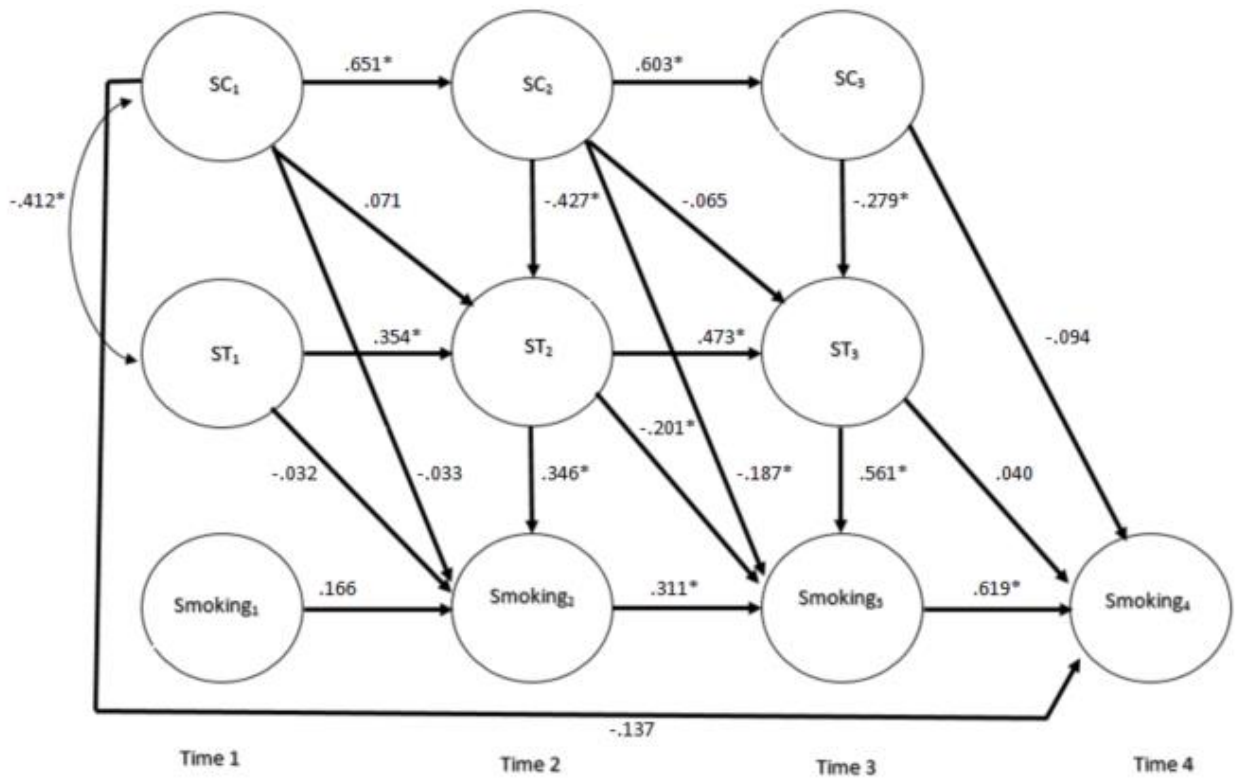


Figure 3.7 Situational Temptations Stimulus Control (Females)

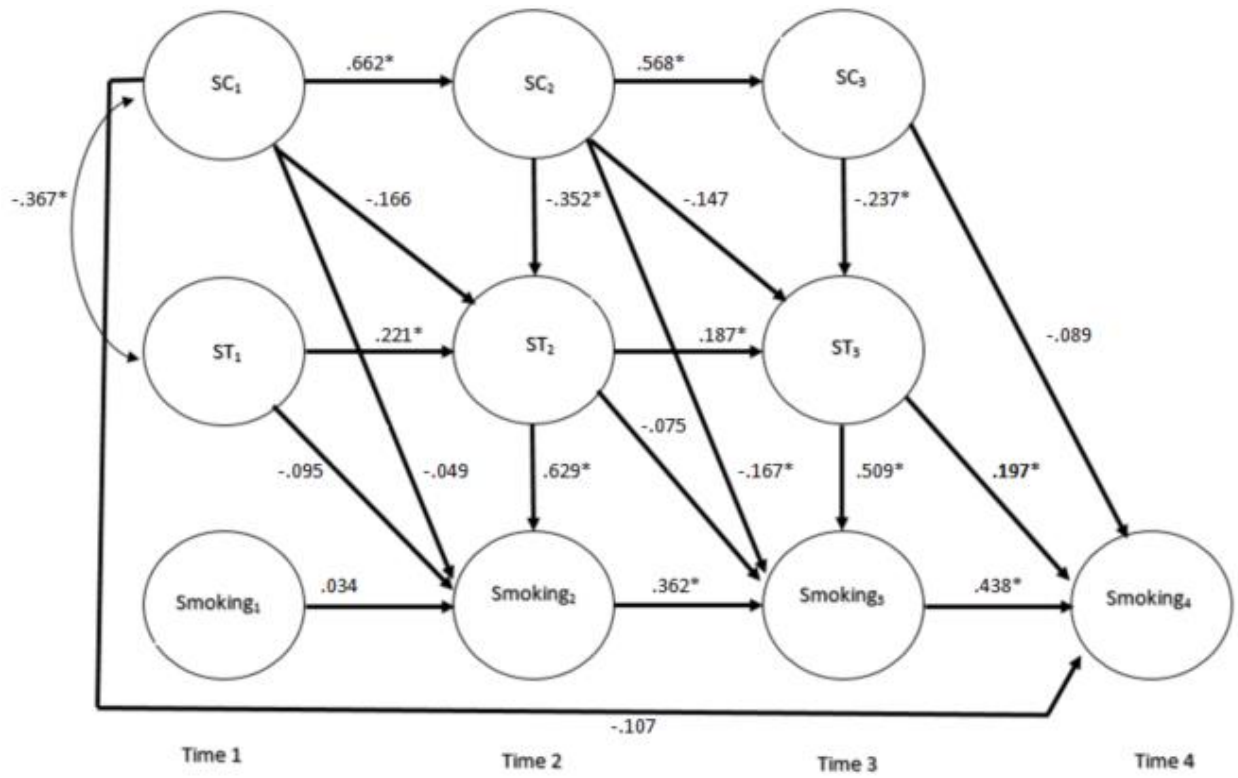


Figure 3.8 Situational Temptations Stimulus Control (White)

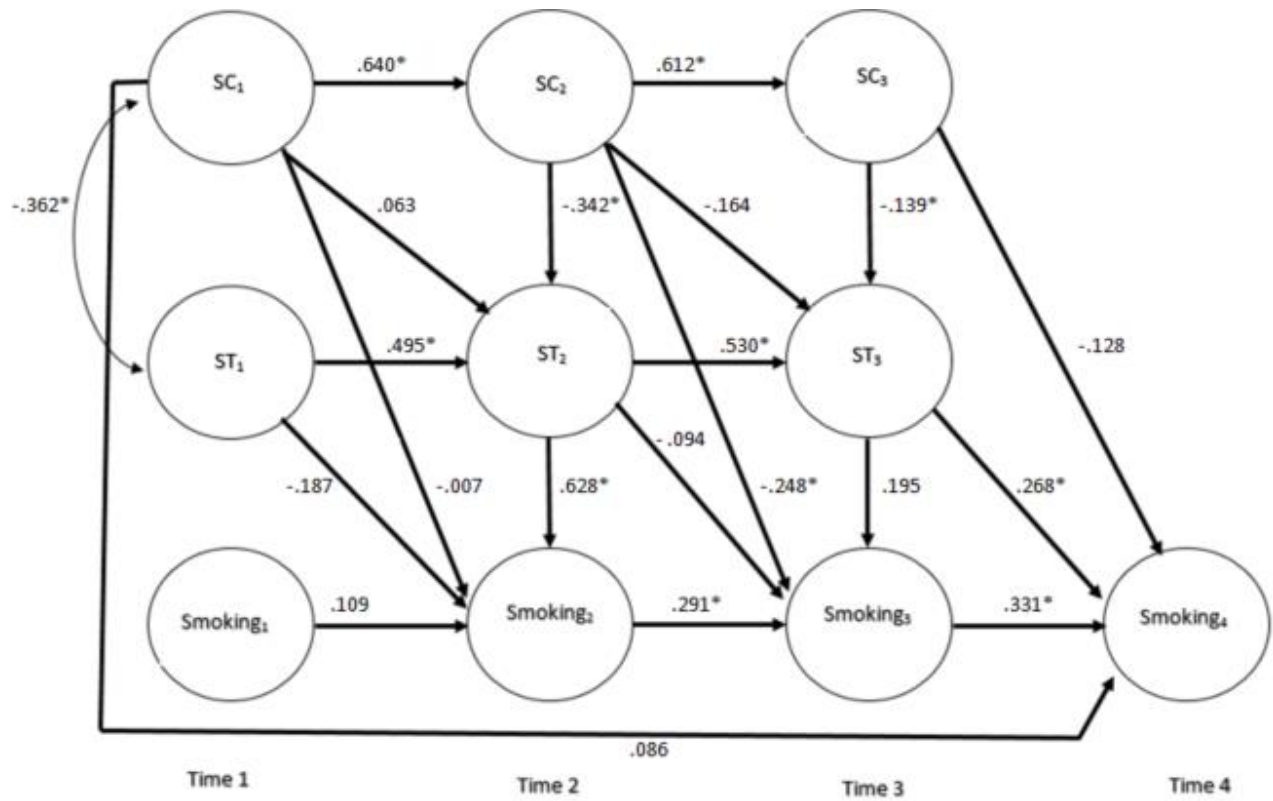


Figure 3.9 Situational Temptations Stimulus Control (Non White)

Paper 4

Conclusions from Studies

Because of the dearth of studies examining the Transtheoretical model's (TTM) mechanisms of smoking prevention on smoking acquisition during adolescence, the overarching objective of this research was to advance our understanding of the causal pathways between processes of change and mediators of smoking acquisition in a longitudinal design. Students at baseline were in the 6th grade and were not smoking and not thinking about smoking within the next 6 months. The purpose of the first study was to investigate the Pros, Cons and Temptations of smoking prevention as intervening variables of 11 different processes of change for smoking prevention as independent variables of smoking acquisition. In total, 33 models were investigated, however only temptations were found to mediate smoking uptake. Dramatic relief, Self-liberation, and Stimulus Control all had small indirect effects on smoking acquisition. The second study aimed to combine the three models into one comprehensive model of smoking prevention, however, the models were too unstable to converge. Thus, it seemed best to keep the single-mediator models and test for measurement invariance across three models instead of one. The single mediator models were the most parsimonious representation of the underlying relationships between temptations to try smoking in middle school and smoking acquisition in early high school. The pragmatic decision to test the models separately led to 3 separate models of smoking prevention. However, we found only two processes, models of Dramatic Relief and models of Stimulus control, were invariant across gender and race, whereas the models with Self-Liberation did not converge. It is possible that the

addition of a few more parameters (i.e. 2 subgroups) in the invariance models increased the complexity of the models too much, which led to some convergence challenges that were difficult to overcome.

Taken together, these findings suggested that there are a few behavioral and cognitive processes of change as early as 7th grade that can have small effects on preventing smoking over 4 years. Thus, it stands to reason that future interventions continue encouraging students to make a commitment to not try cigarettes, stay away from situations or people who may tempt them to try smoking, and to maintain their emotional awareness of the risks of smoking. More research is needed to better understand the ways in which the treatment interventions modified these processes. In addition, future studies should consider evaluating smoking acquisition over a longer period of time and investigate how the influences of the processes and mediators of change in middle school influences smoking behaviors later in high school.

Notwithstanding the limitations of this research, the most important and most relevant tests of the usefulness and generalizability of the statistical mediation models assessed in the present series of studies would involve directly applying the results to interventions. If an intervention group that received behavioral mechanism-based tailoring outperformed a group with less specific tailoring, this finding would both help validate the overall approach and create the opportunity for further refinement of existing interventions. Future studies should evaluate the efficacy of these interventions by including a control group in the study design, and a new cycle of mediation analyses could be conducted to further refine and test the mechanisms of

change. Ultimately, faster and more effective intervention messages would be developed to focus on the most important processes and mediators of behavior change.

APPENDICES

Appendix A. Study Measures

Process Variables Items

Consciousness Raising

- I thought about the benefits of staying smoke free.
- I paid attention to anti-smoking messages.
- I paid attention to the warnings about second-hand smoke.

Dramatic Relief

- Hearing about the risks of smoking worried me.
- I got angry with ads that encouraged kids to smoke.
- Stories about people who die from smoking scared me.

Environmental Reevaluation

- I thought about how smoking pollutes the environment.
- I thought about how smoking could hurt people around me.
- I noticed that the people I look up to don't smoke.

Self Reevaluation

- Staying away from smoking was something I felt proud of.
- I felt good about myself as a nonsmoker.
- I felt more responsible about my choice not to smoke.

Social Liberation

- I noticed most public places don't allow smoking.
- I noticed that smoking is less acceptable these days.
- Smoke free places encouraged me to stay smoke free.

Counter Conditioning

- I found better ways to cope with stress, instead of smoking.
- I found better things to do with my friends than smoking.
- I realized instead of smoking, I'd rather do something else.

Stimulus Control

- I tried to avoid people who smoke.
- I stayed away from anyone who might push me to try smoking.
- I ignored cigarette ads that tried to make smoking seem cool.

Helping Relationships

- I had someone who listened when I needed to talk about smoking.
- I had someone who supported my decision to stay smoke-free.
- I could trust people close to me to help me avoid smoking.

Reinforcement Management

- I thought of how I could reward myself for staying smoke-free.
 - I got praised for being a nonsmoker.
-

Others rewarded me for being a nonsmoker.

Self-Liberation

I promised myself to stay away from smoking.

I told people I care about that I will stay smoke-free.

I reminded myself that staying smoke-free is my choice.

Refusal Assertiveness

I thought that if anyone pushed me to try smoking, I'd just say no.

I refused to be pressured into trying smoking.

Mediator Items

Pros

smoking makes kids get more respect from others

kids who smoke have more friends

kids who smoke go out on more dates

smoking helps people to cope better with frustrations

smoking cigarettes is pleasurable

smoking cigarettes relieves tension

Cons

smoking stinks

smoking can affect the health of others

smoking cigarettes is hazardous to peoples health

cigarettes smoking bothers other people

smoking is a messy habit

smoking makes teeth yellow

Temptations

When my friends offer me a cigarette

whit it is difficult to refuse a cigarette

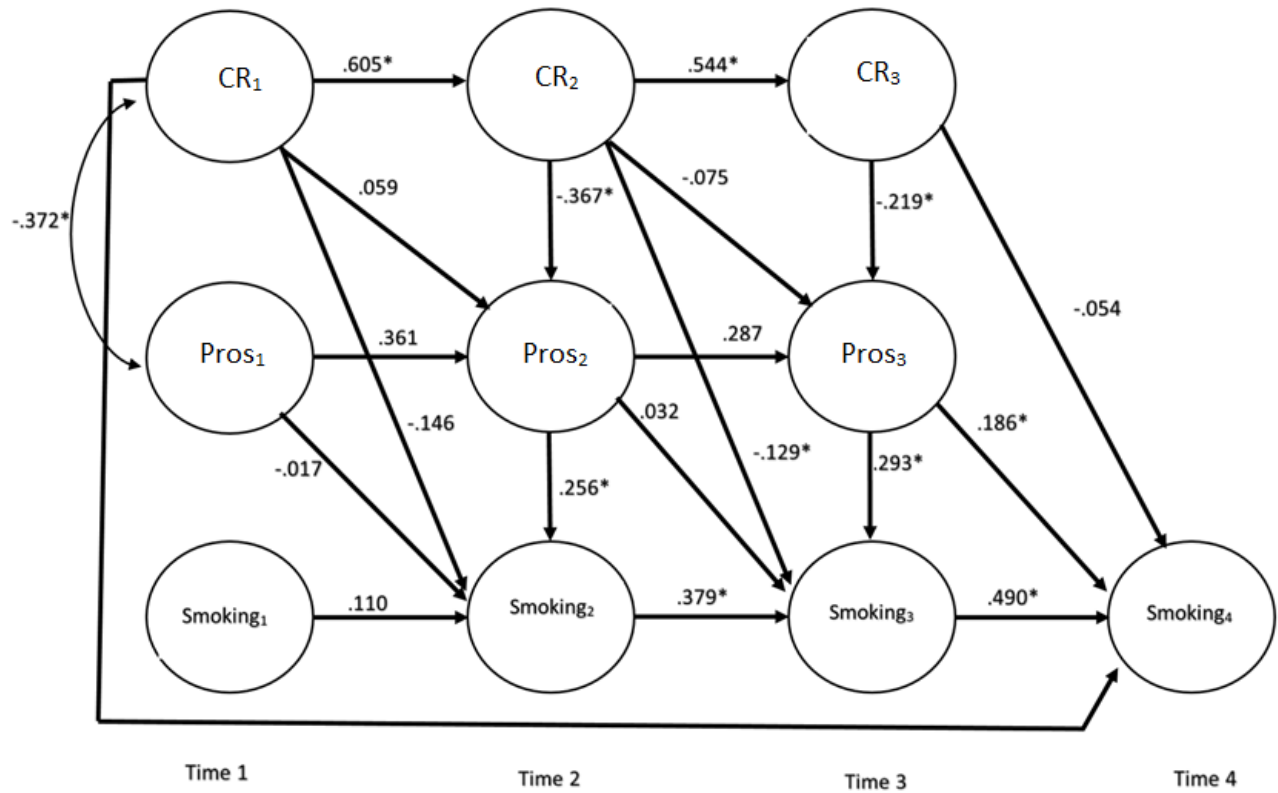
when I am very angry about something or someone

when things are not going my way and I am frustrated

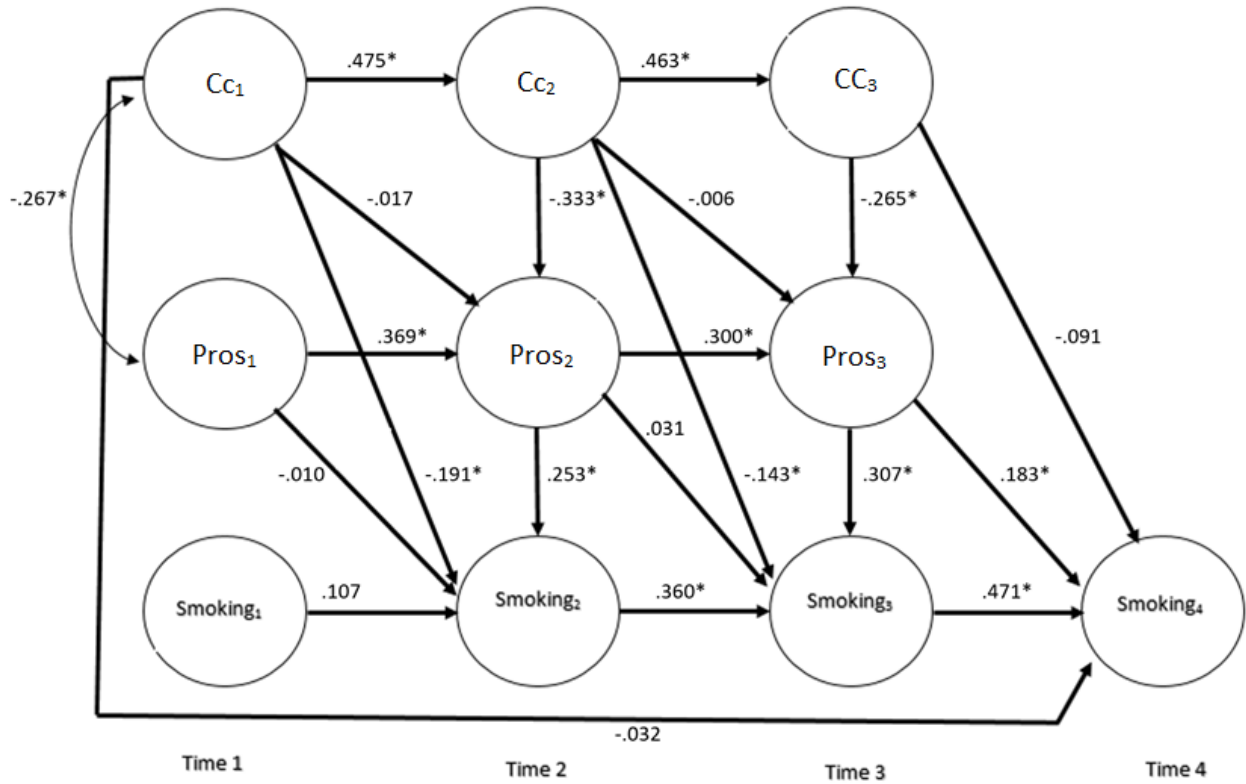
when I feel I need a lift

when I realize I have not smoked in a while

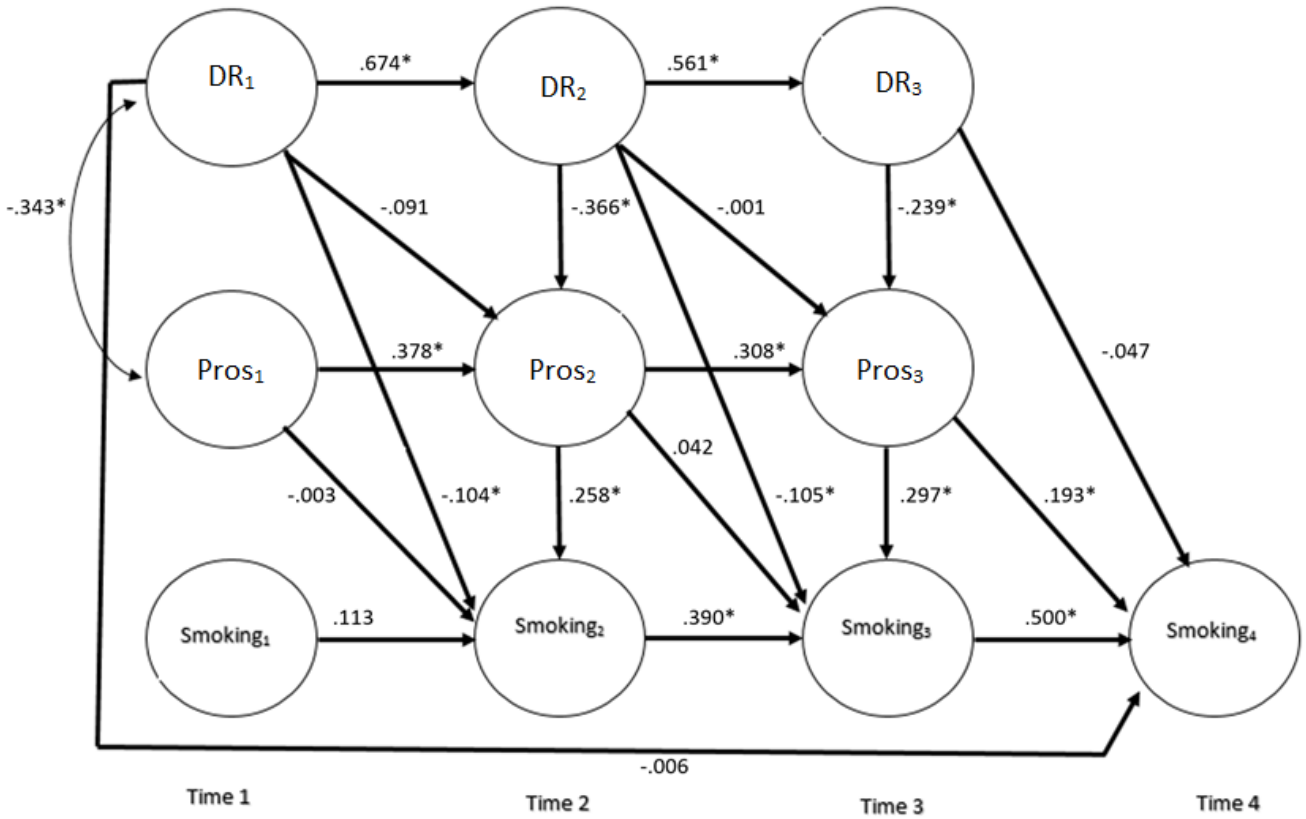
Appendix B. Single Mediator Path Models with Standardized Estimates



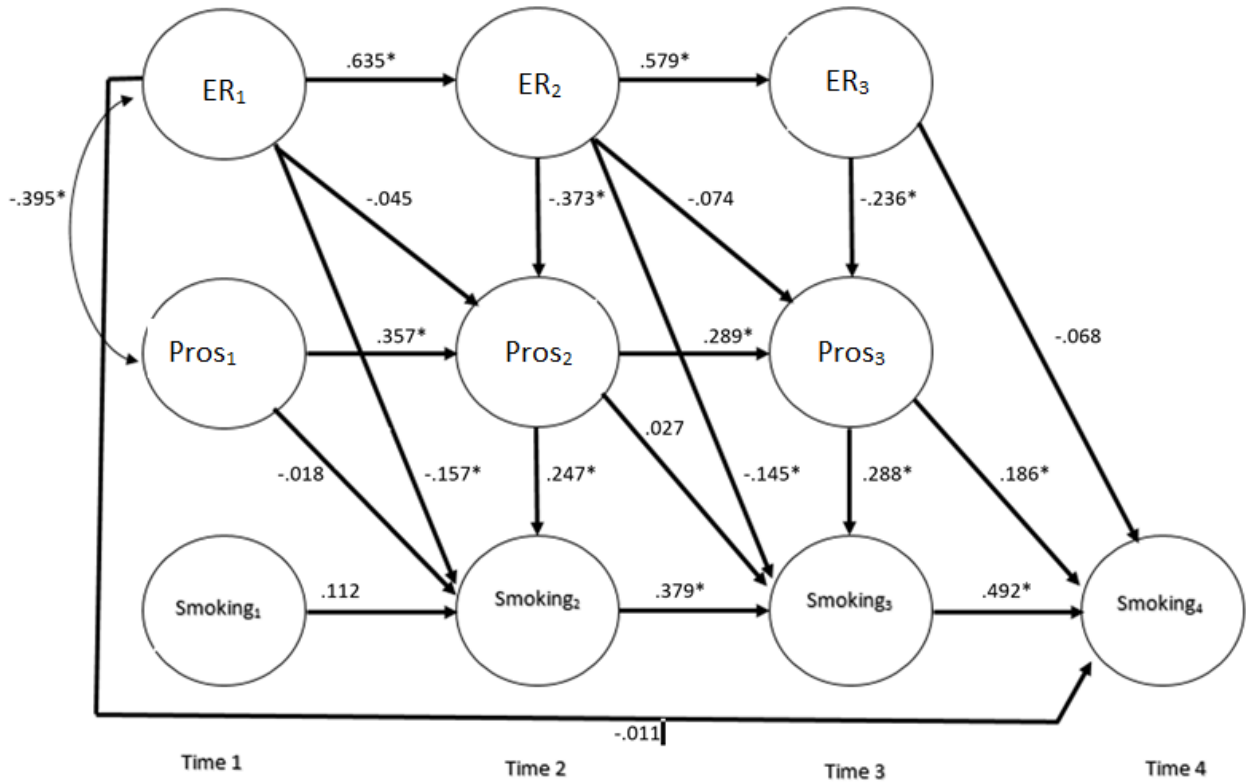
Single Mediator Model of the Pros of smoking and Consciousness Raising



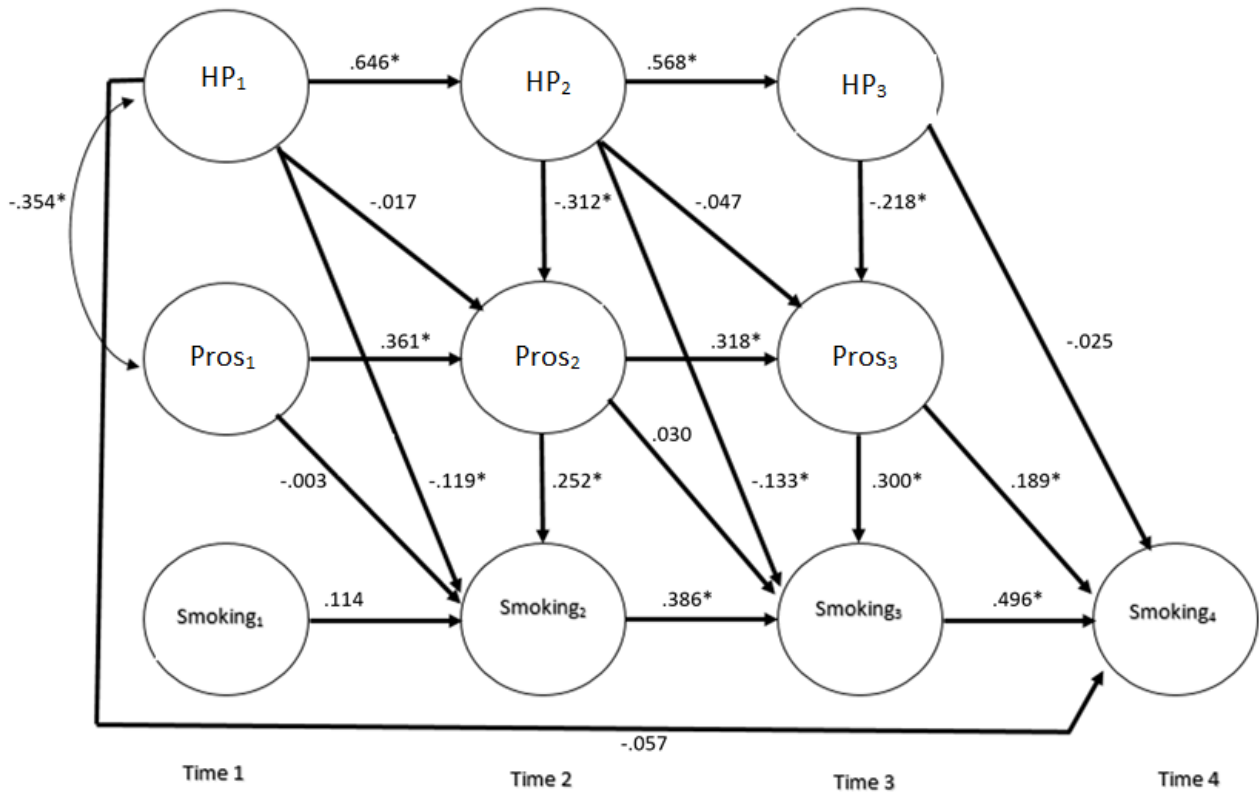
Single Mediator Model of the Pros of smoking and Counter Conditioning



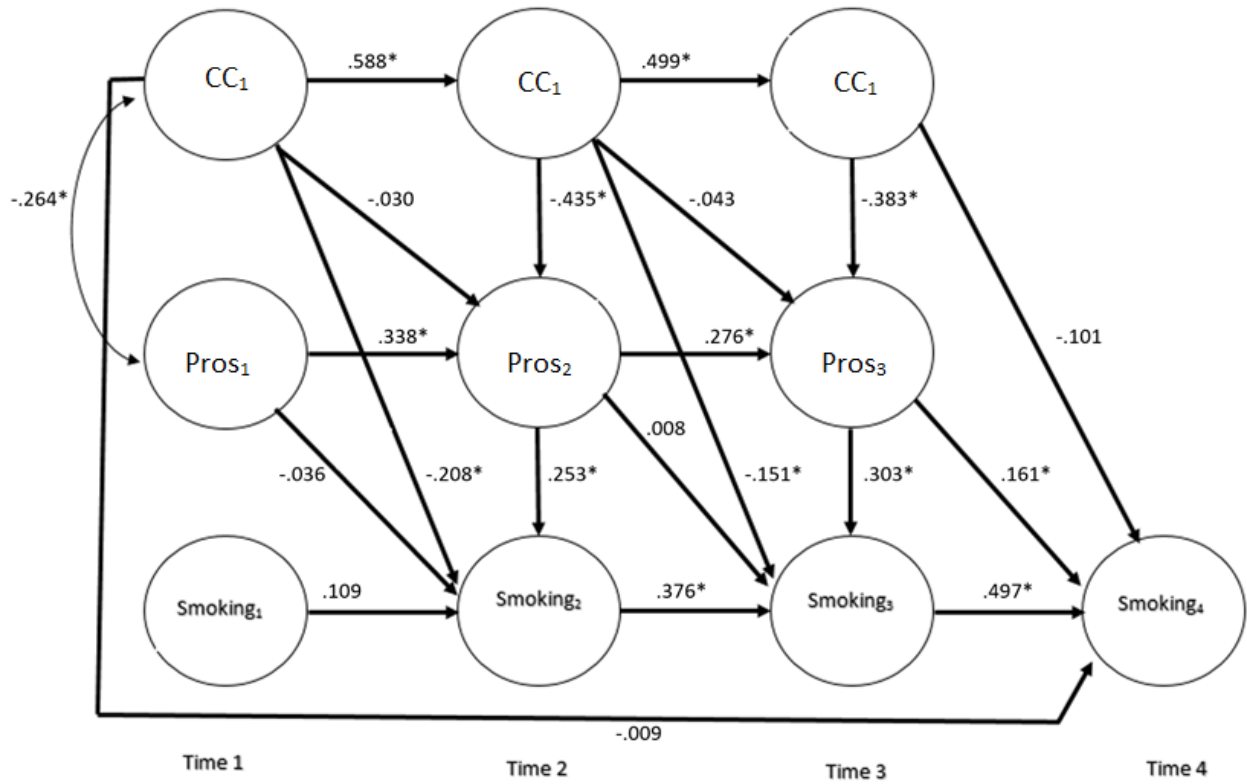
Single Mediator Model of the Pros of smoking and Dramatic Relief



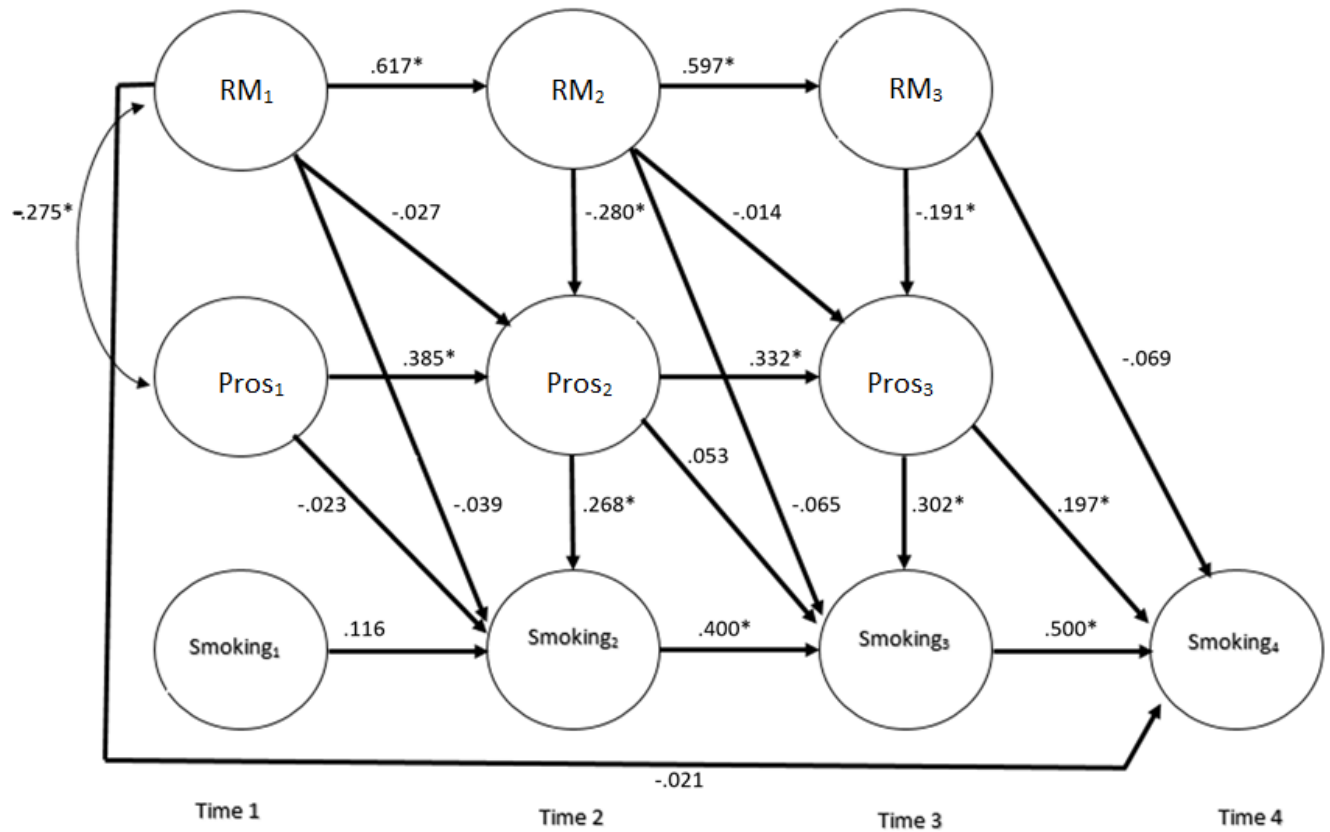
Single Mediator Model of the Pros of smoking and Environmental Reevaluation



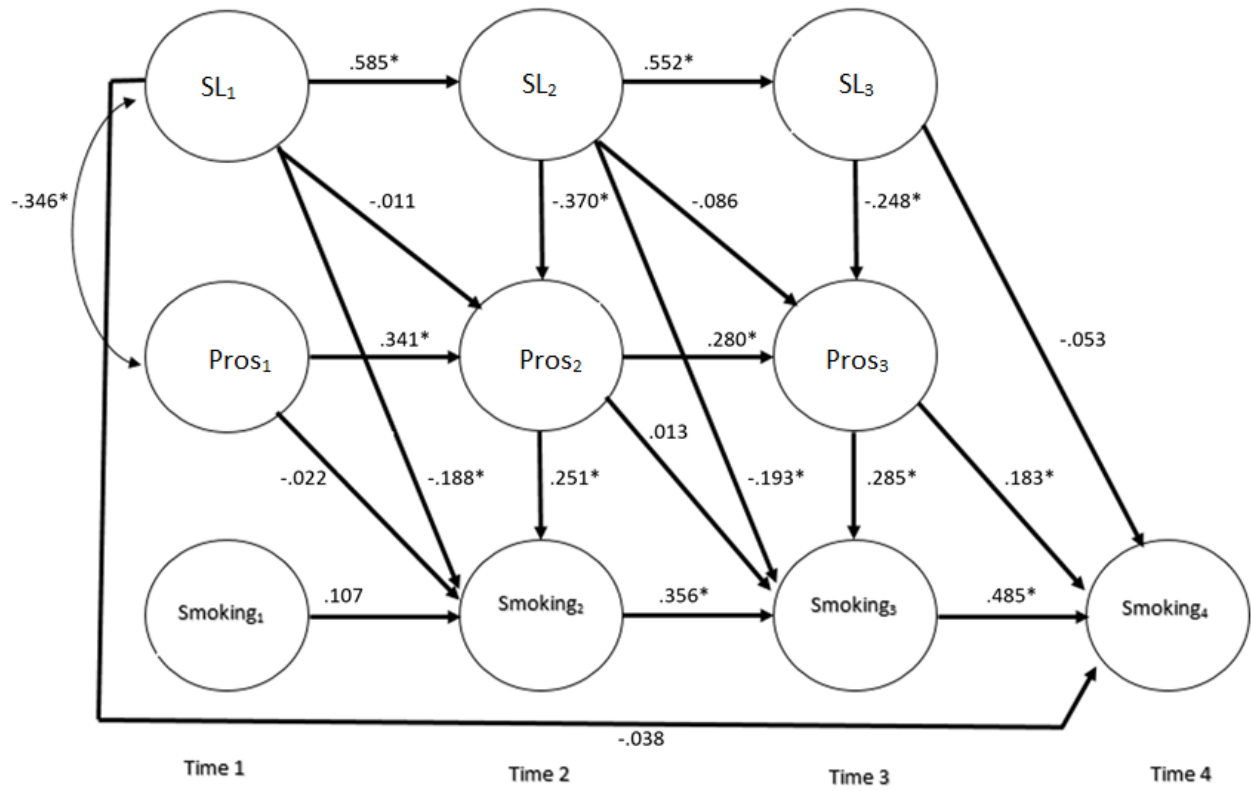
Single Mediator Model of the Pros of smoking and Helping Relationships



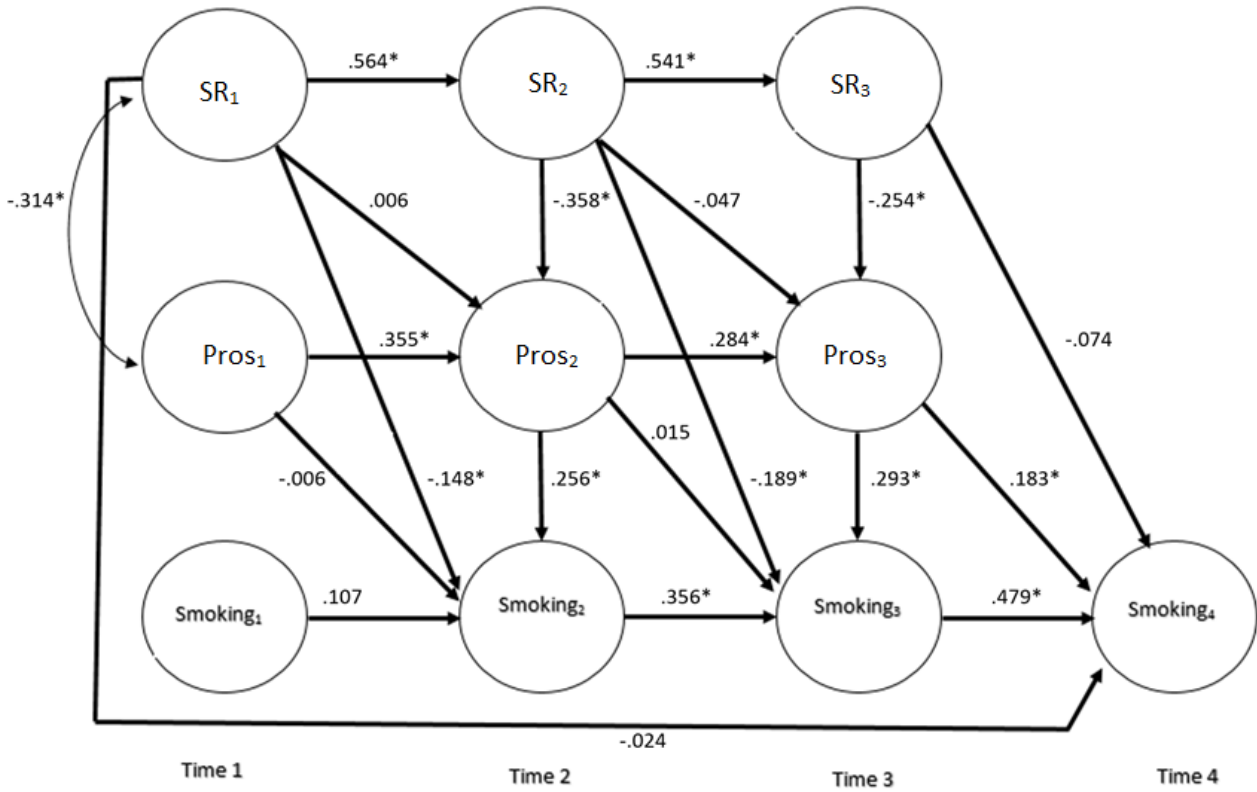
Single Mediator Model of the Pros of smoking and Refusal Assertiveness



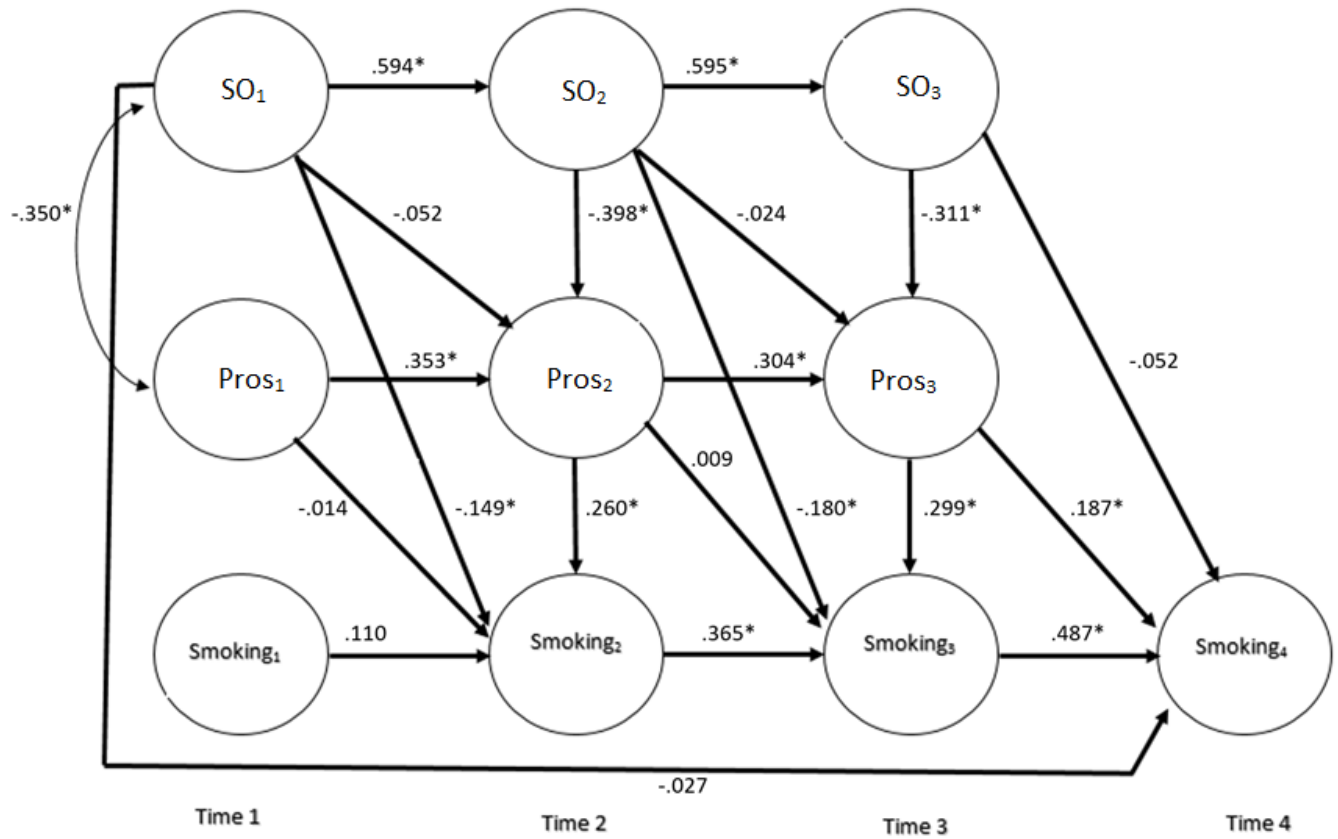
Single Mediator Model of the Pros of smoking and Reinforcement Management



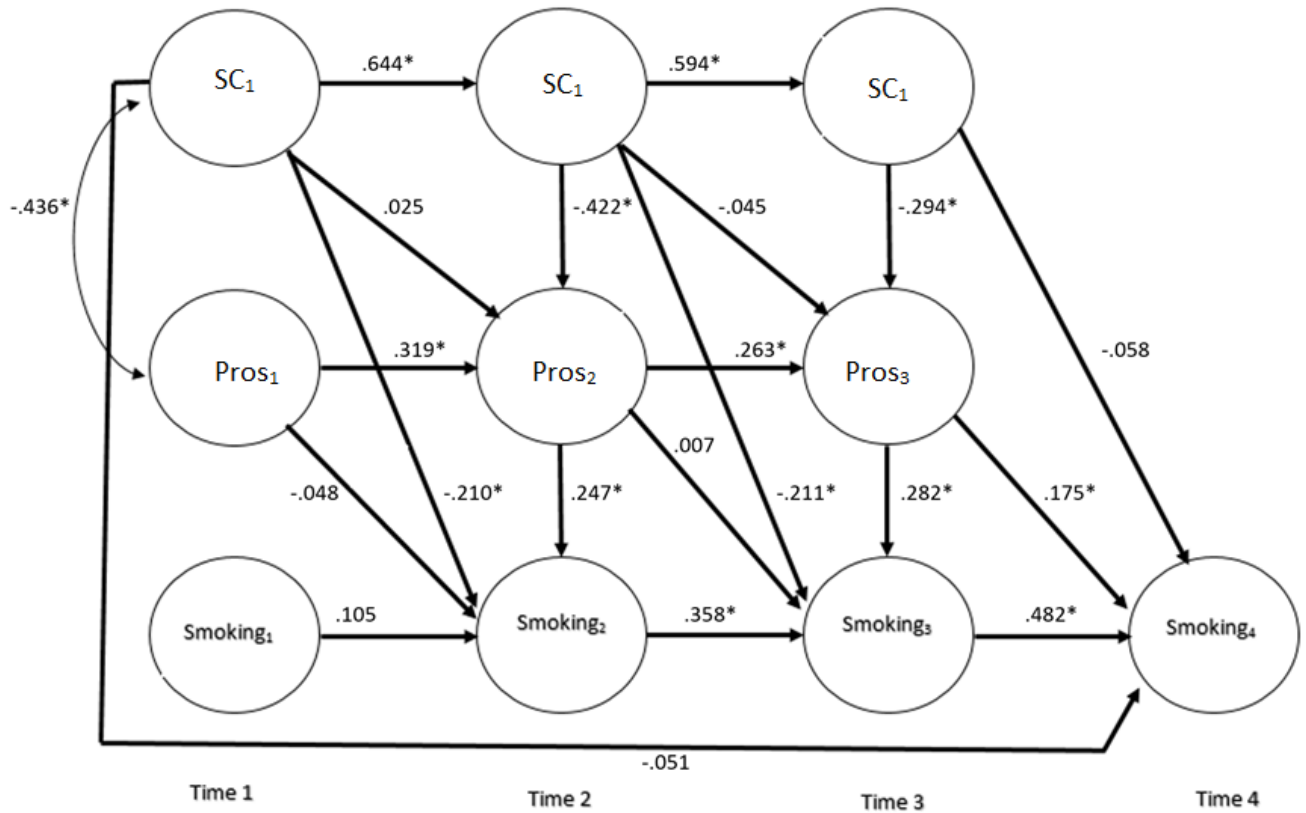
Single Mediator Model of the Pros of smoking and Self-Liberation



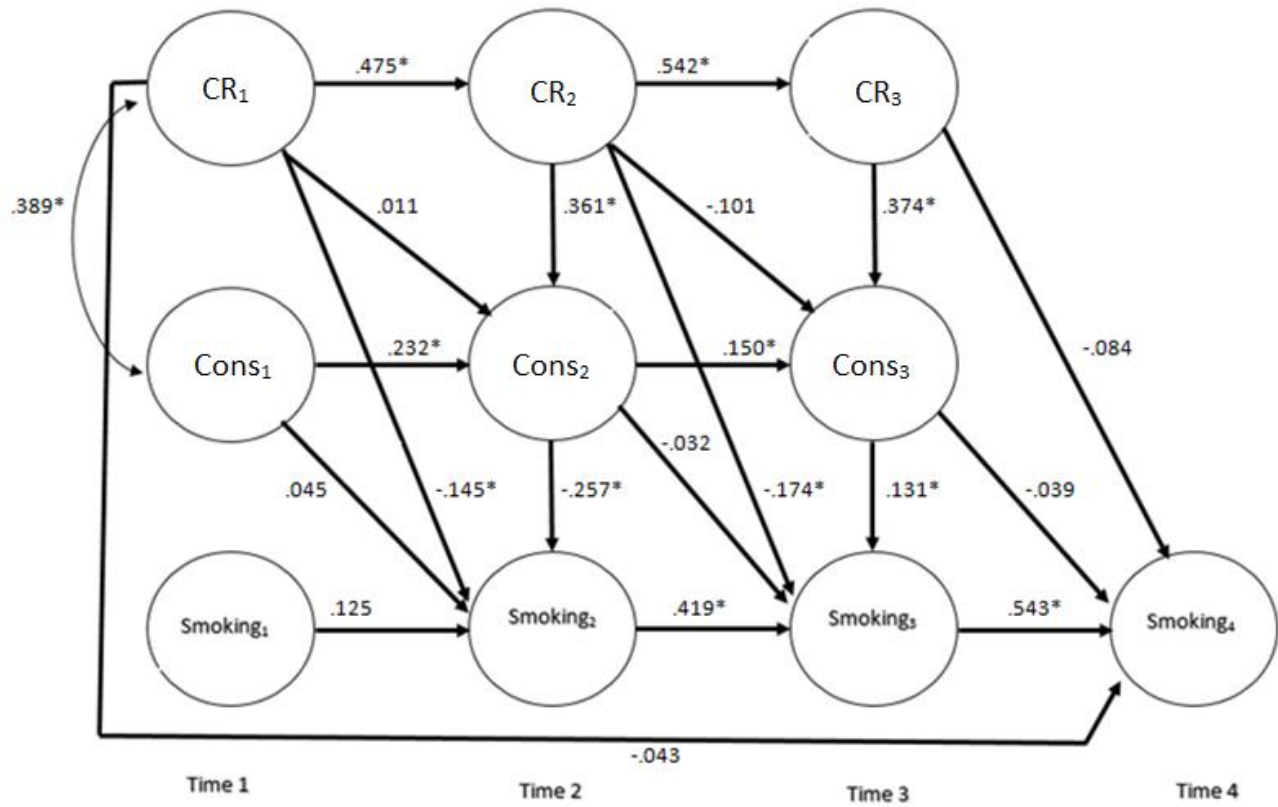
Single Mediator Model of the Pros of smoking and Self-Reevaluation



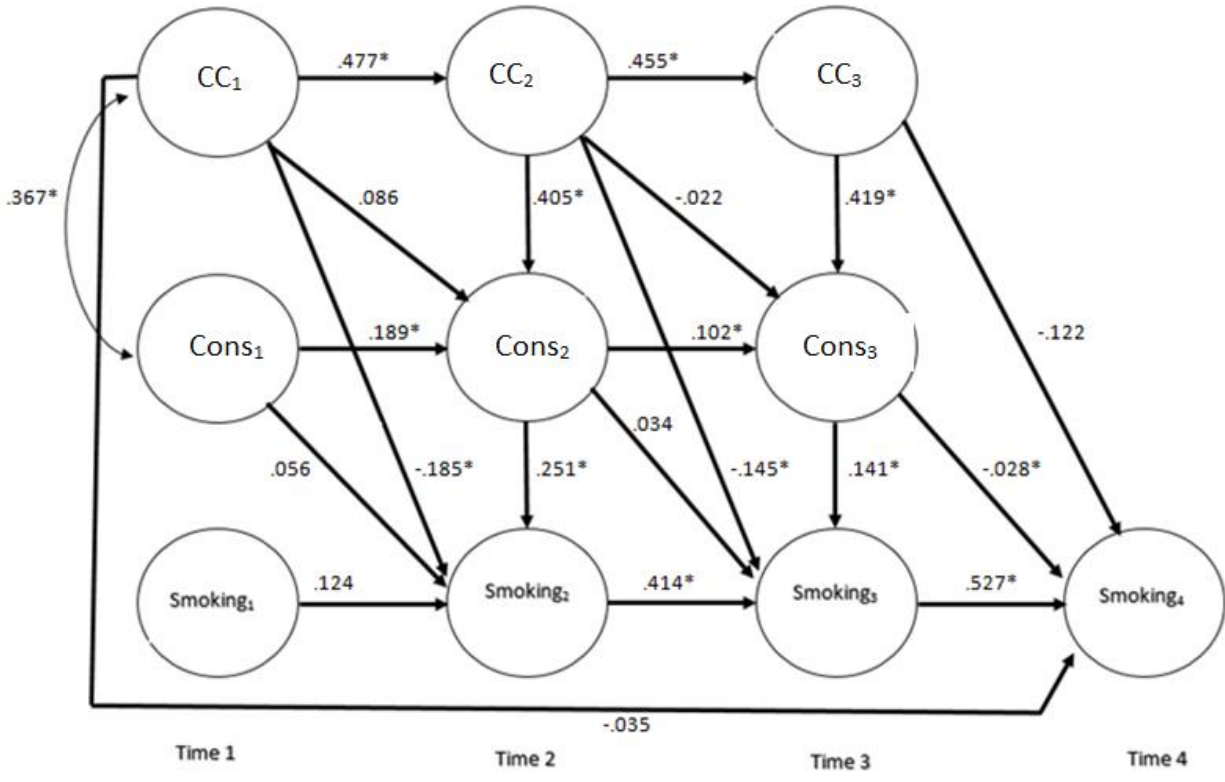
Single Mediator Model of the Pros of smoking and Social Liberation



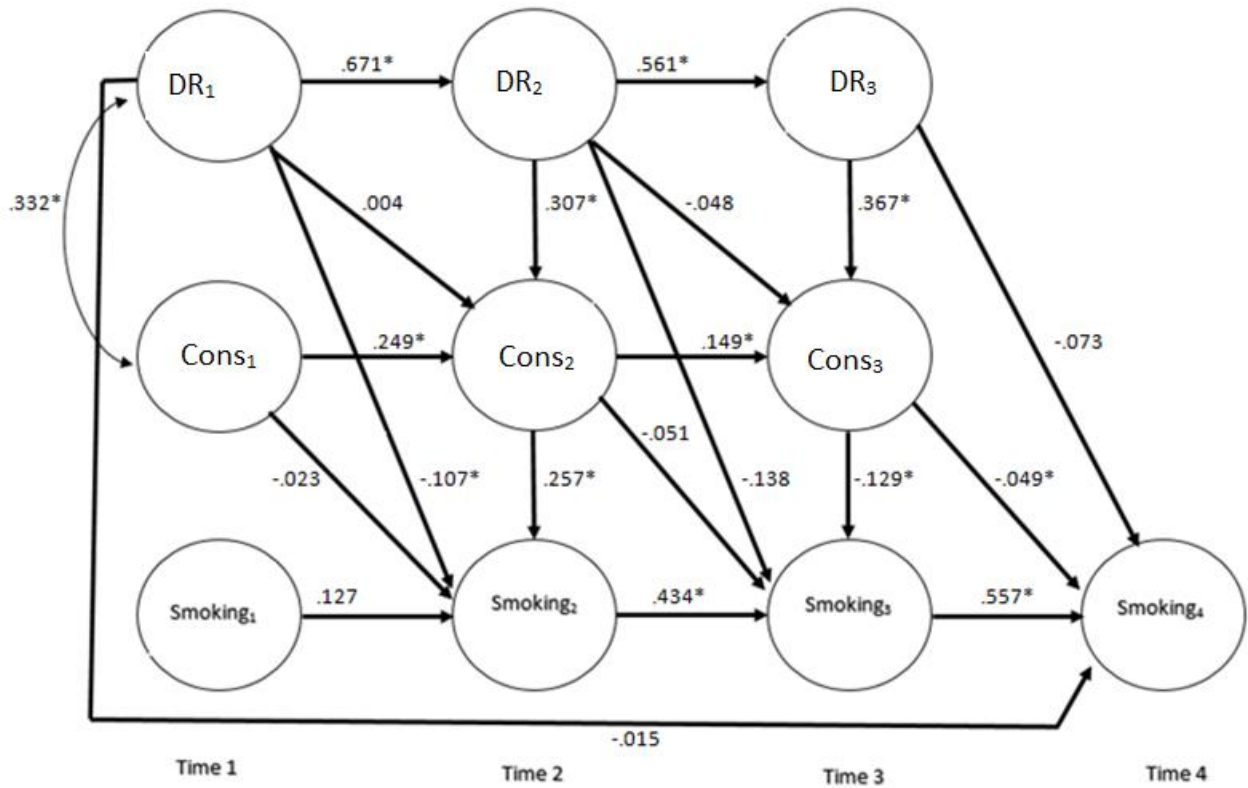
Single Mediator Model of the Pros of smoking and Stimulus Control



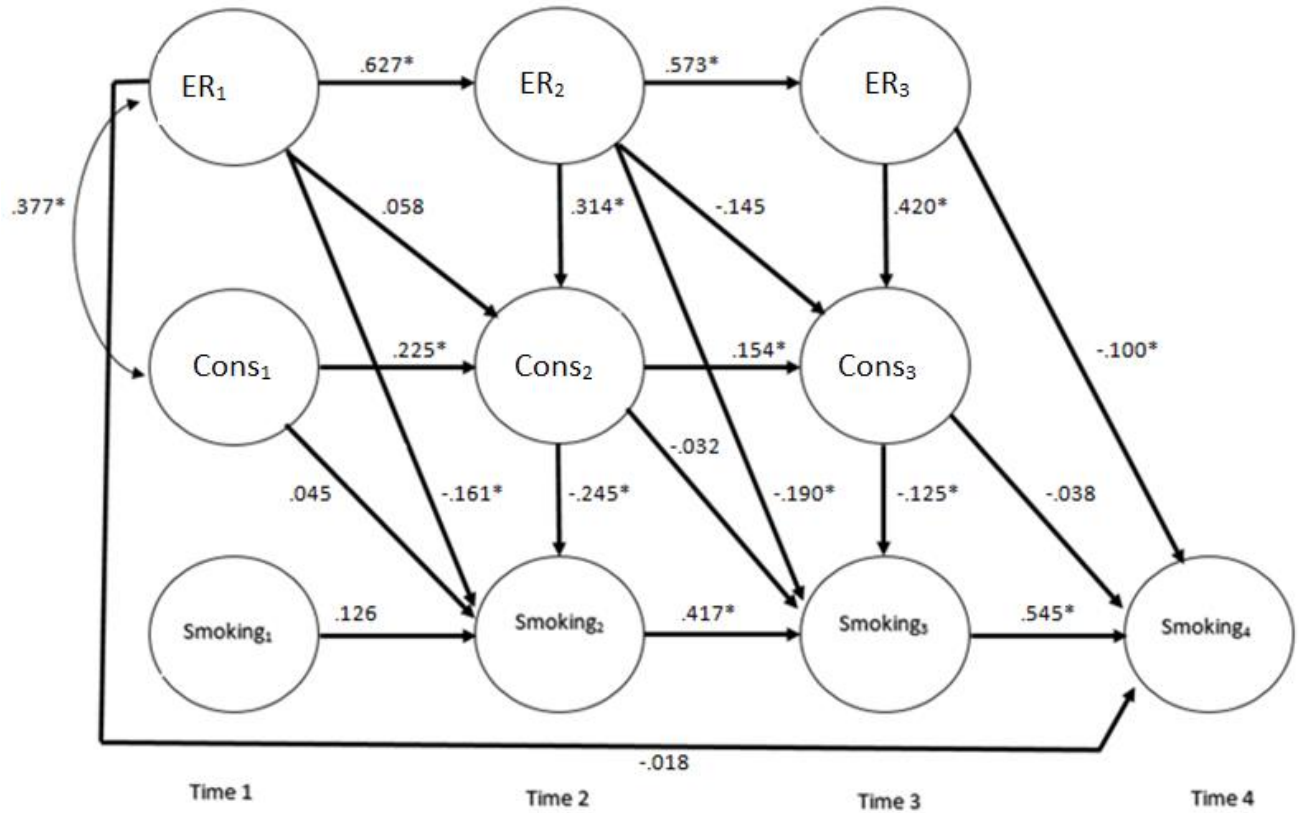
Single Mediator Model of the Cons of smoking and Consciousness Raising



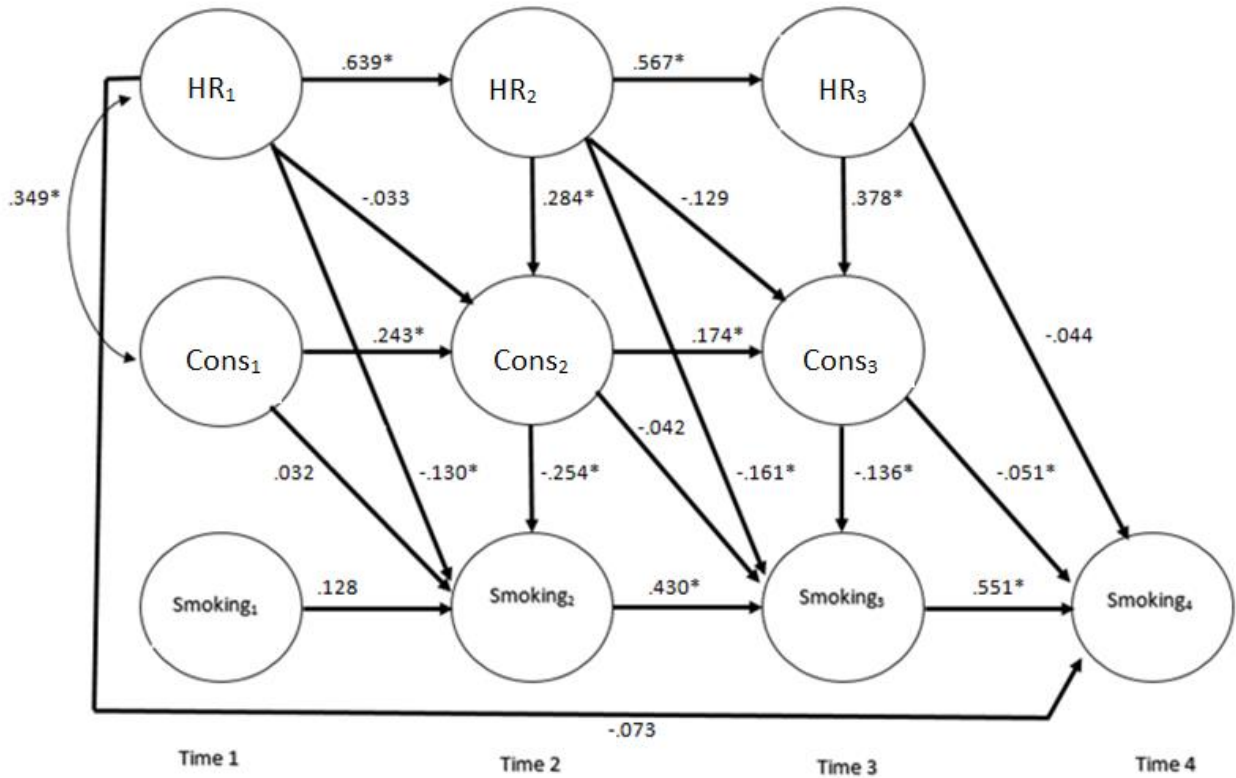
Single Mediator Model of the Cons of smoking and Counter Conditioning



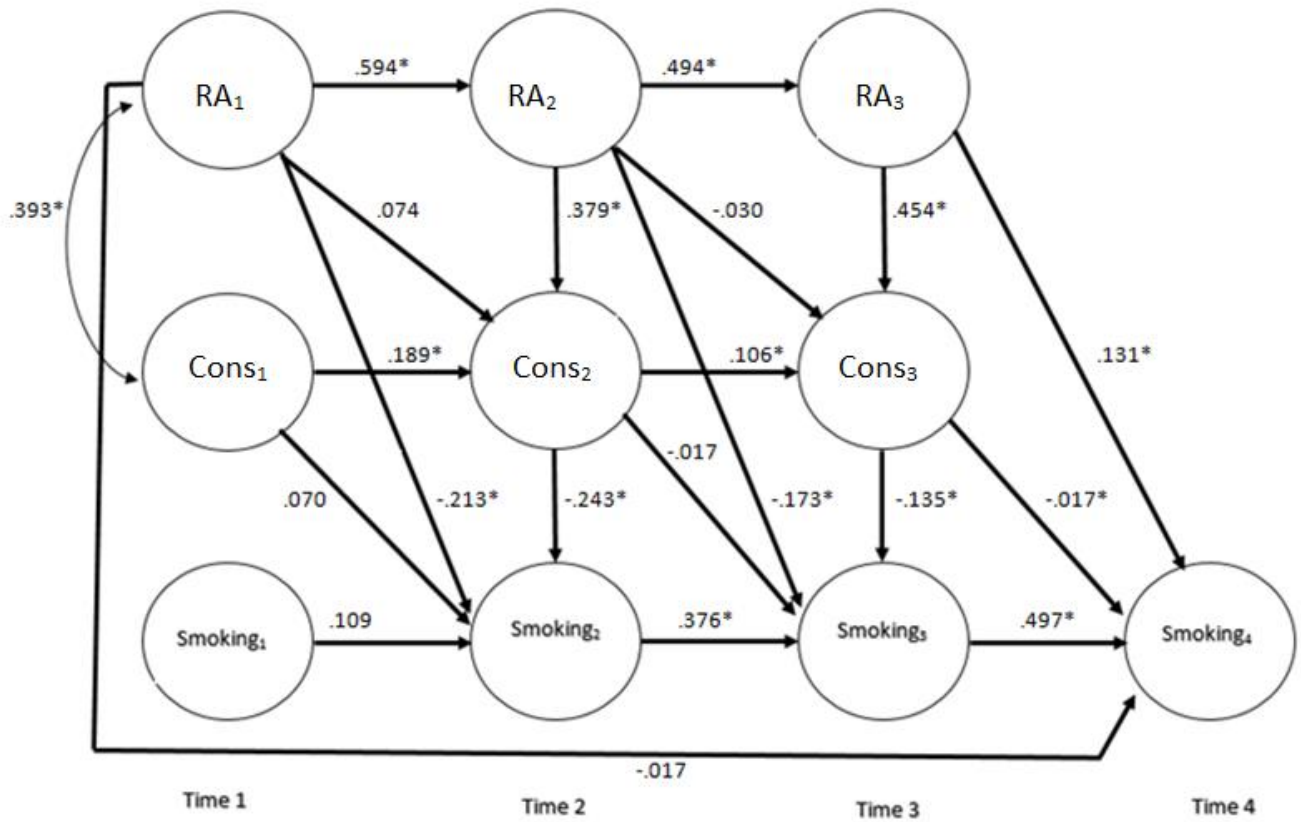
Single Mediator Model of the Cons of smoking and Dramatic Relief



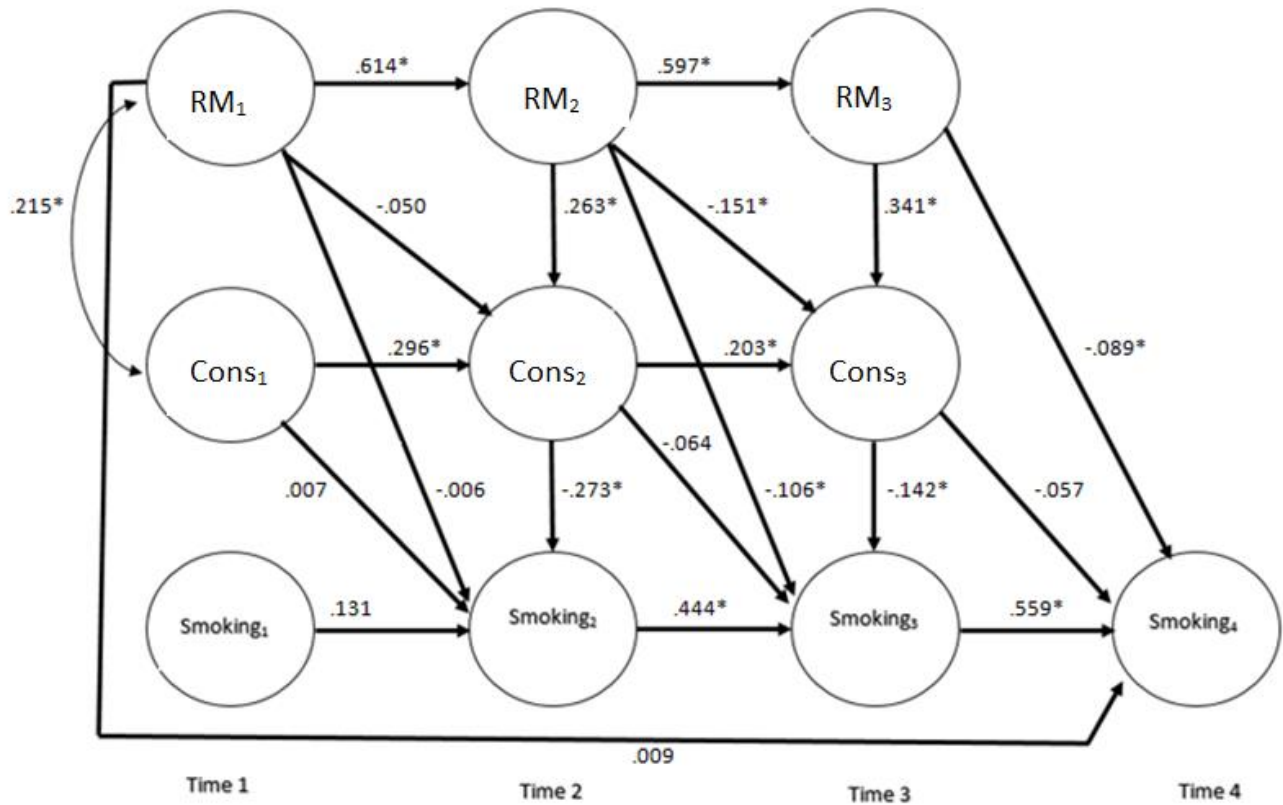
Single Mediator Model of the Cons of smoking and Environmental Reevaluation



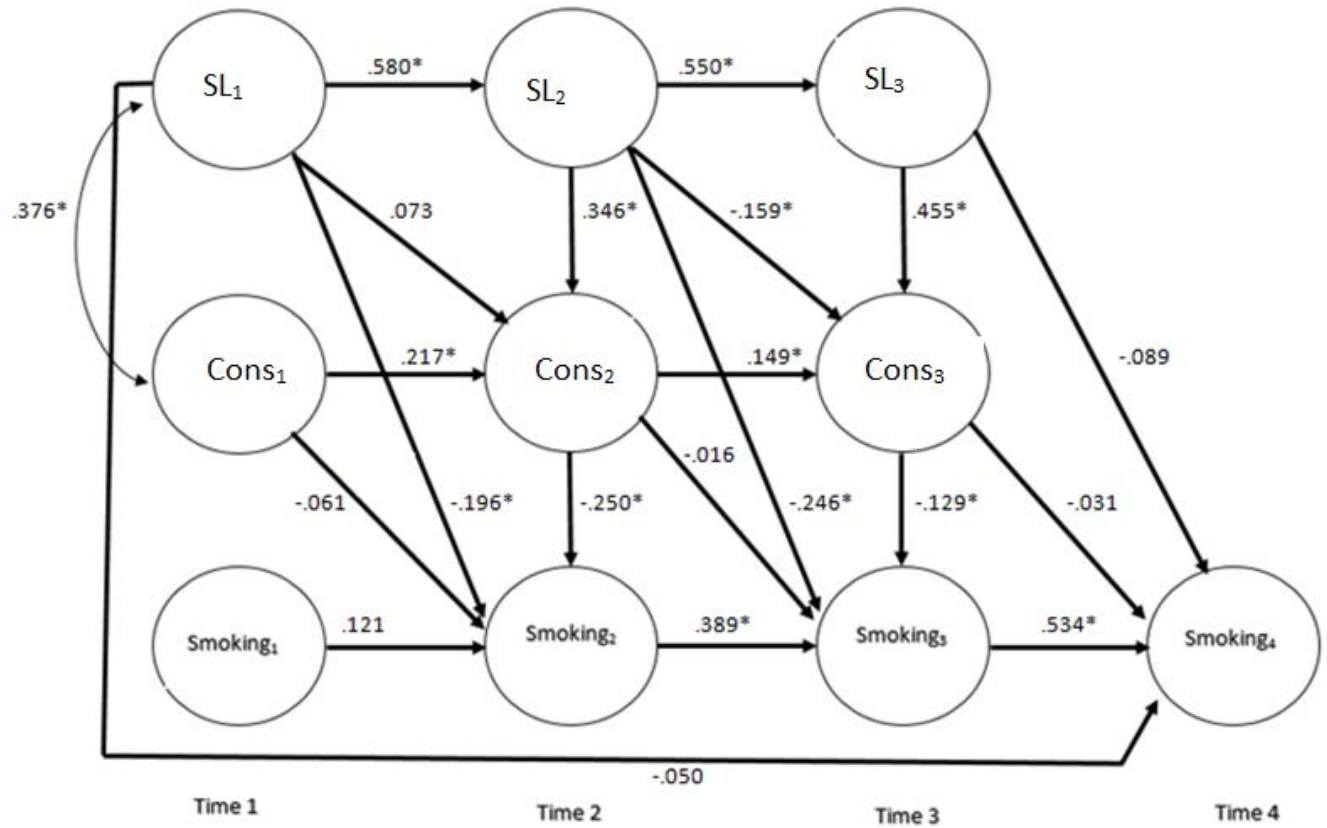
Single Mediator Model of the Cons of smoking and Helping Relationships



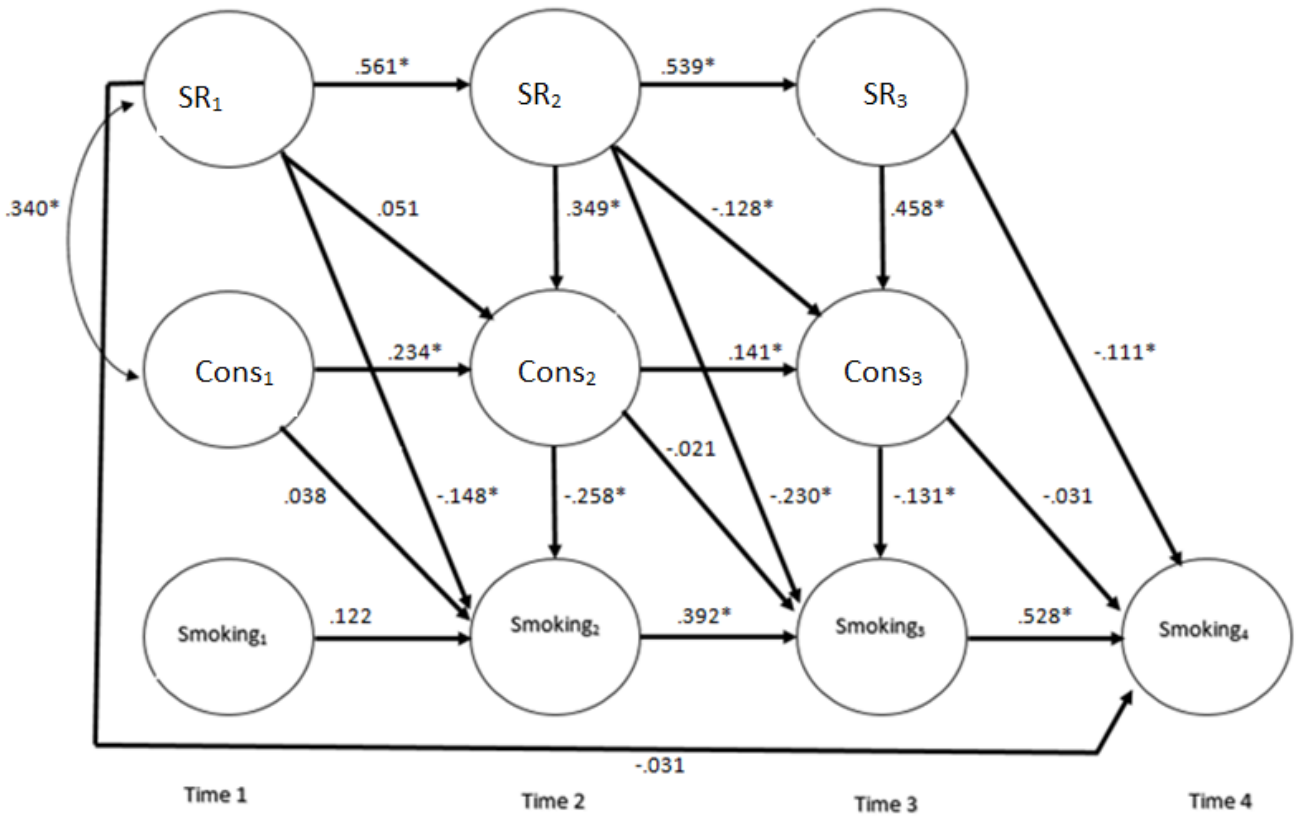
Single Mediator Model of the Cons of smoking and Refusal Assertiveness



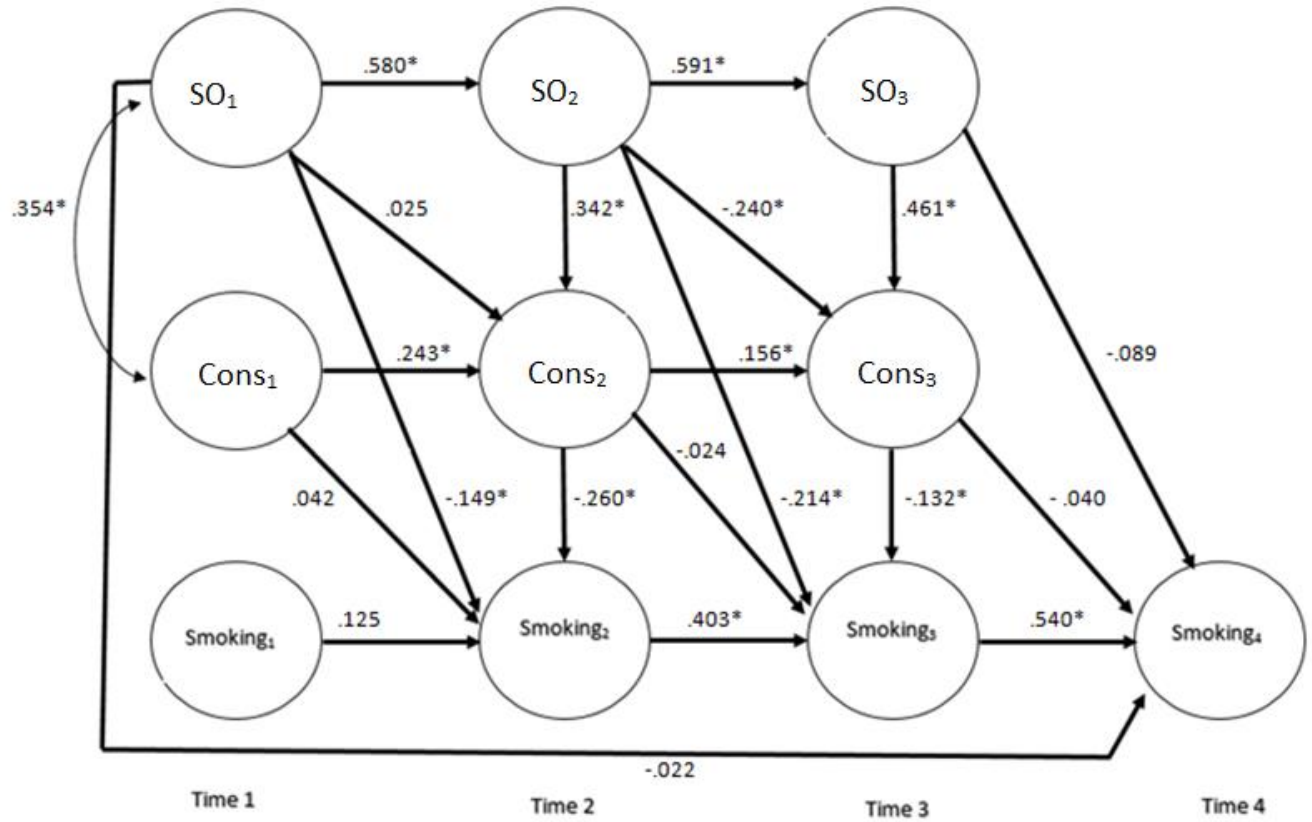
Single Mediator Model of the Cons of smoking and Reinforcement Management



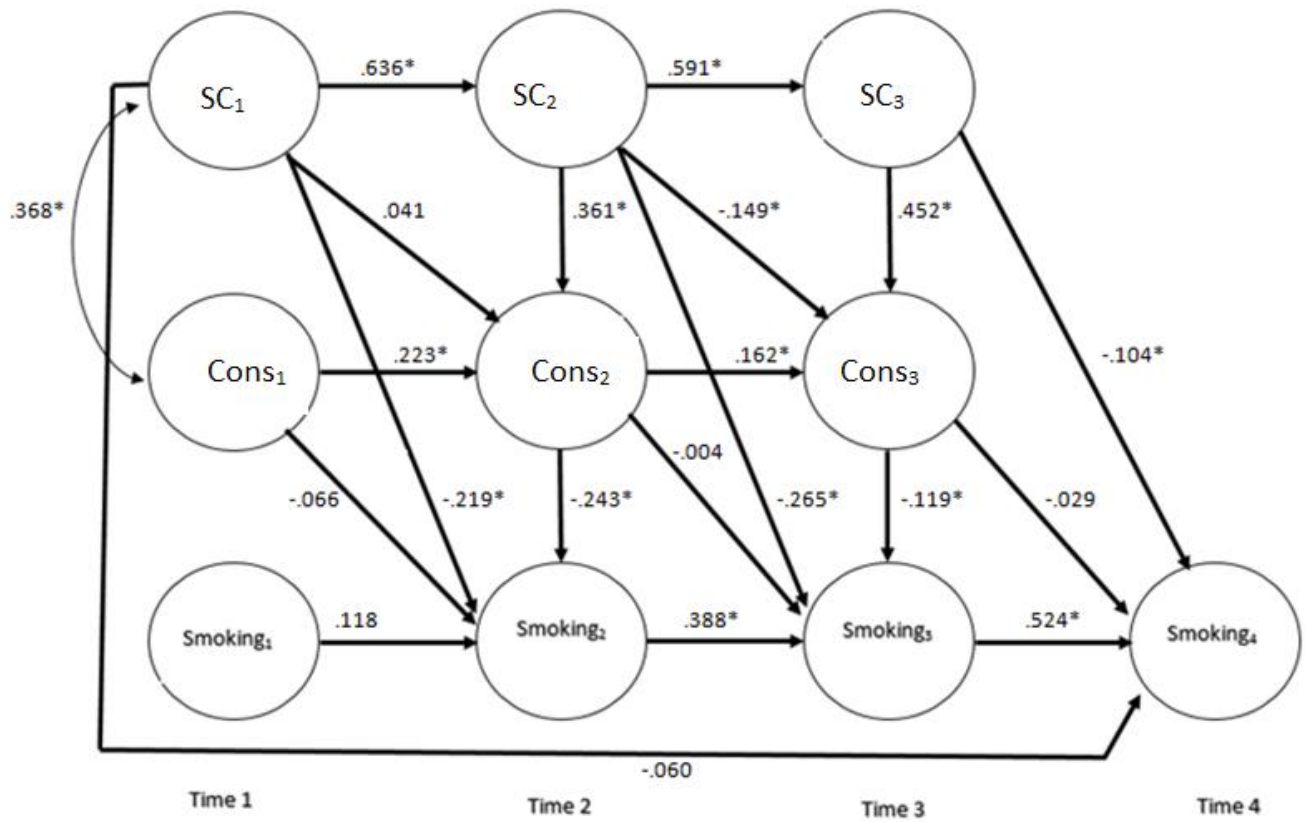
Single Mediator Model of the Cons of smoking and Self-Liberation



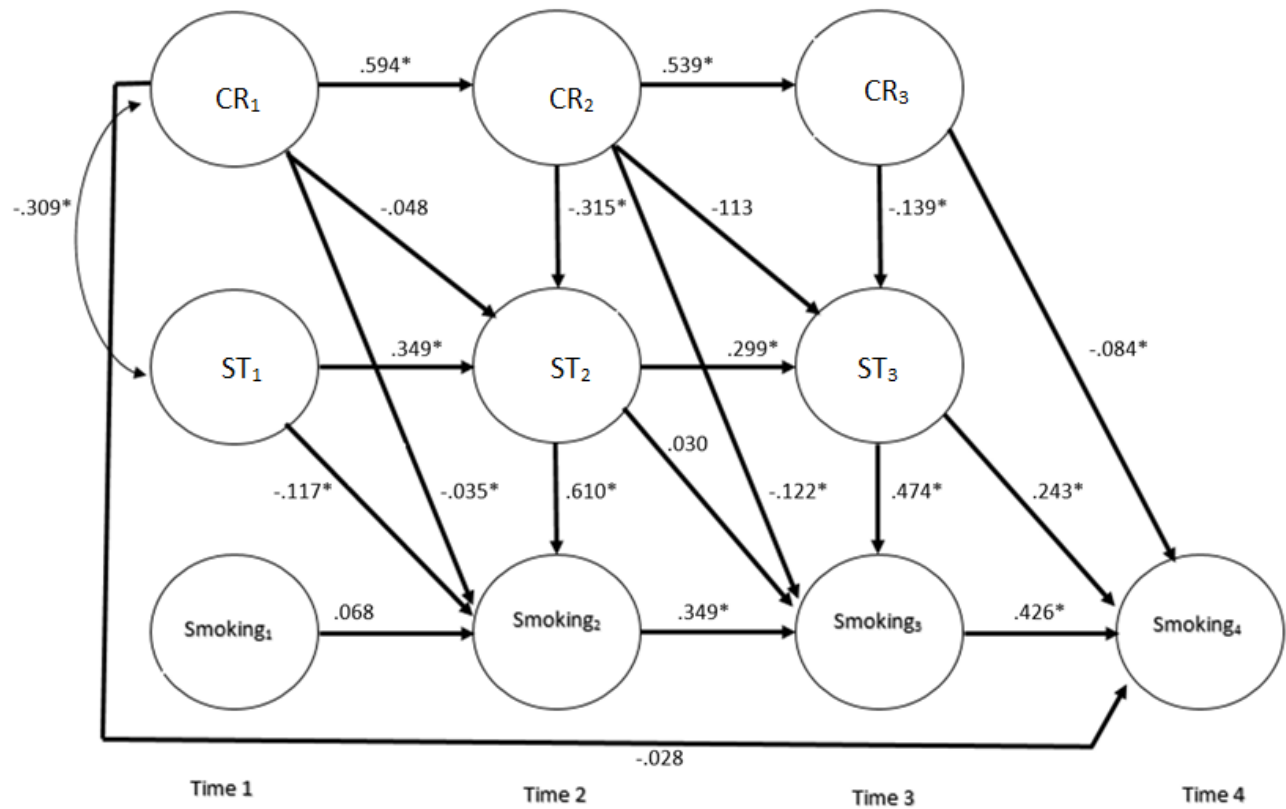
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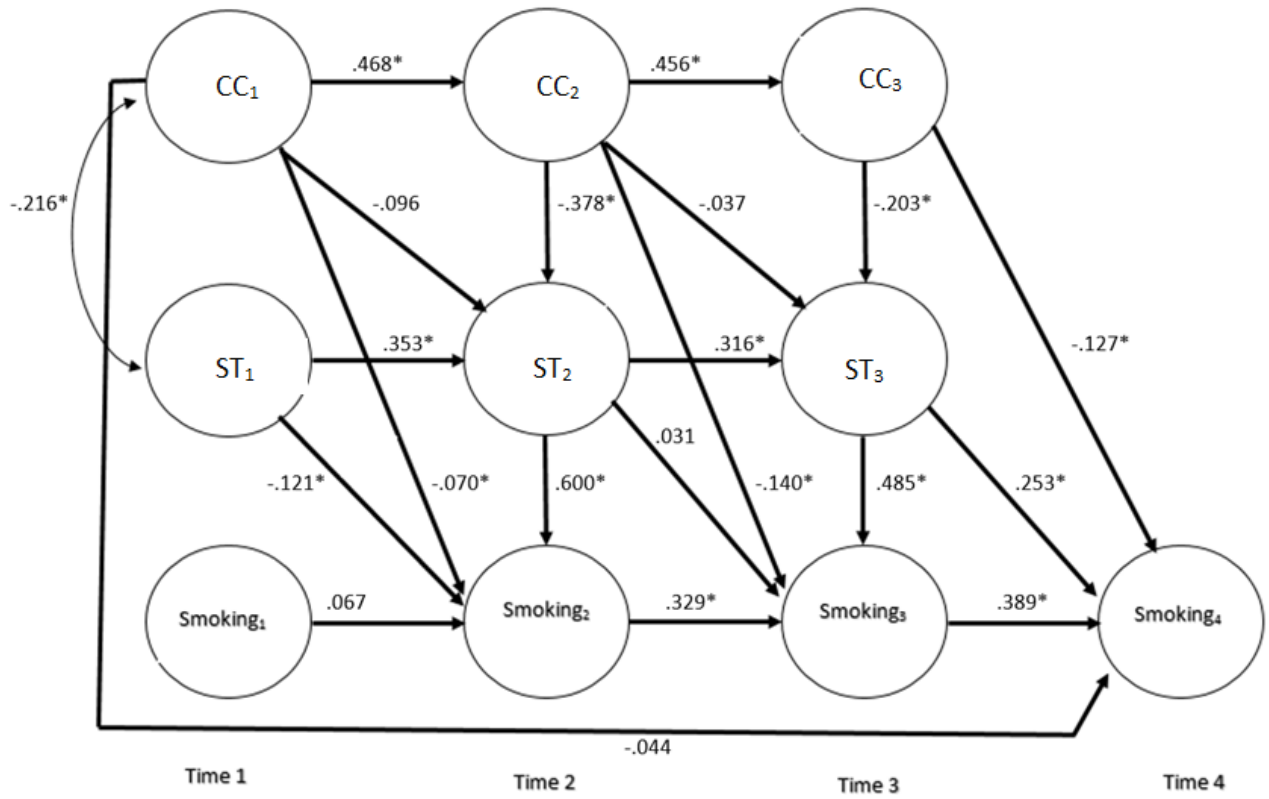
Single Mediator Model of the Cons of smoking and Social Liberation



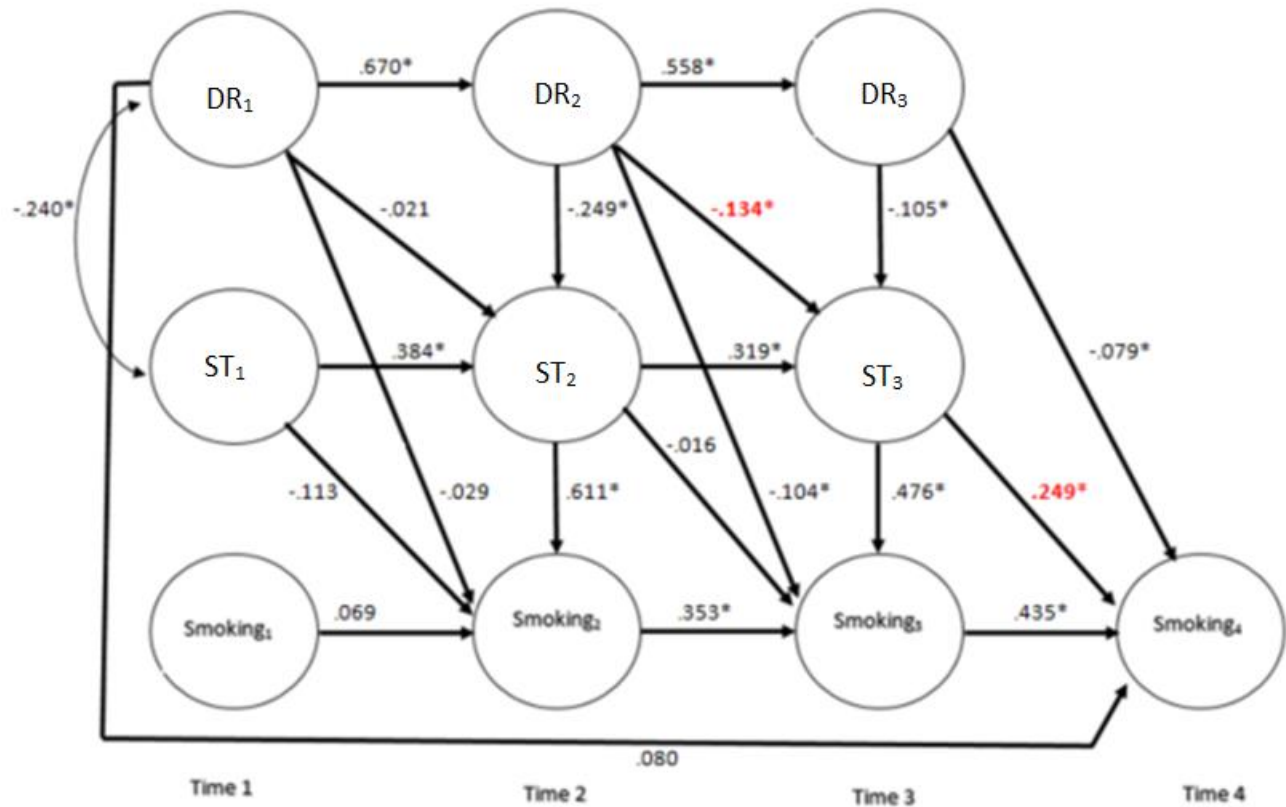
Single Mediator Model of the Cons of smoking and Stimulus Control



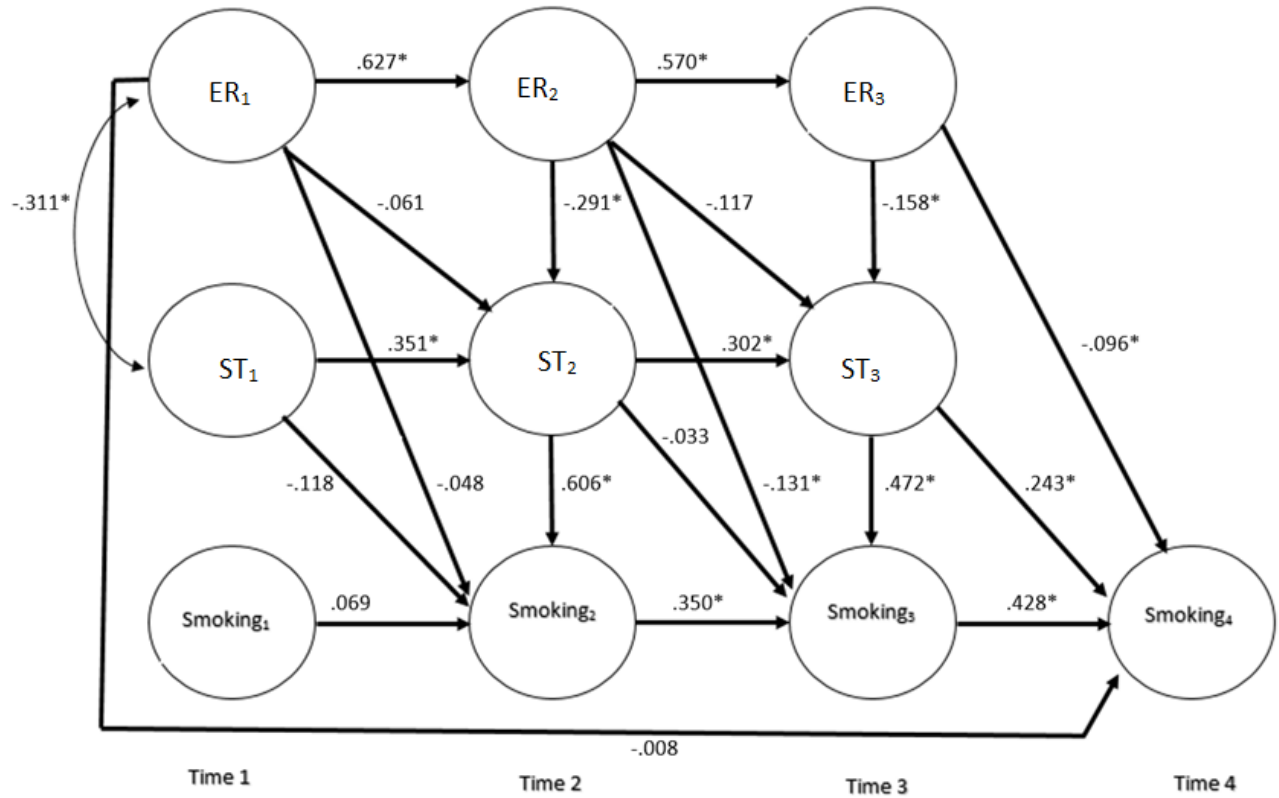
Single Mediator Model of the Situational Temptations of smoking and Consciousness Raising



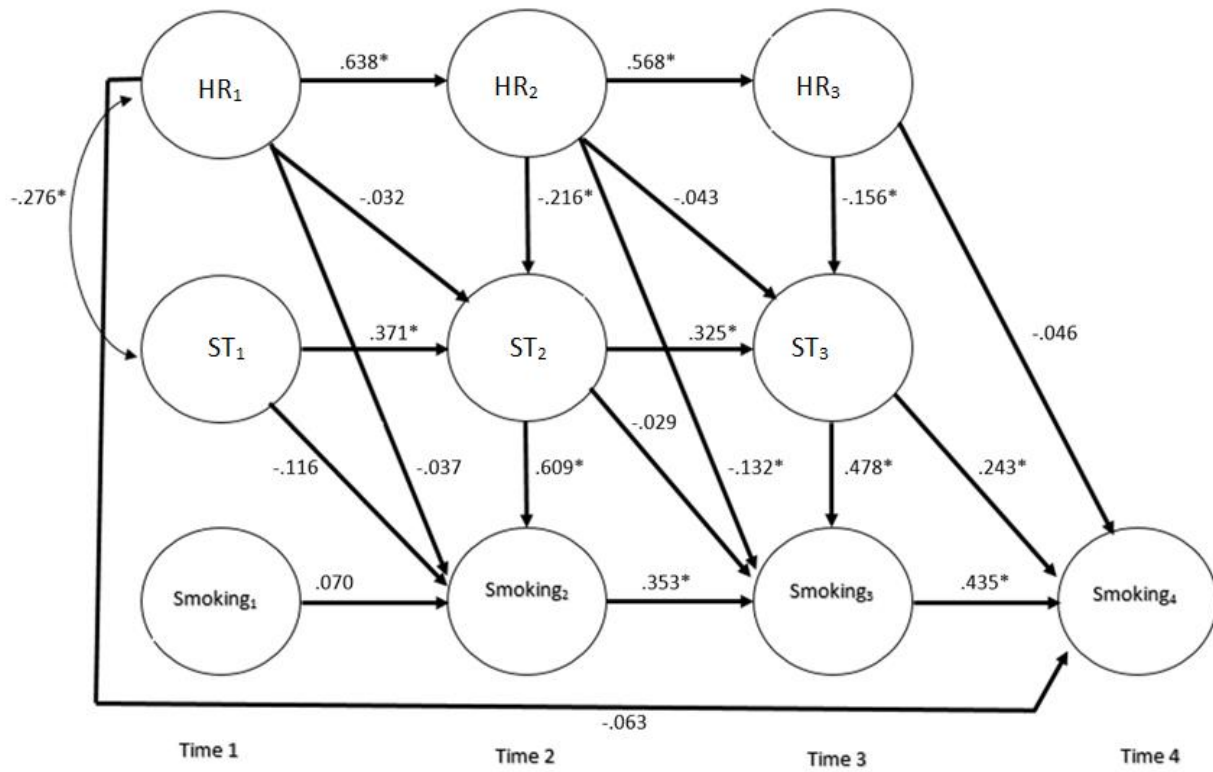
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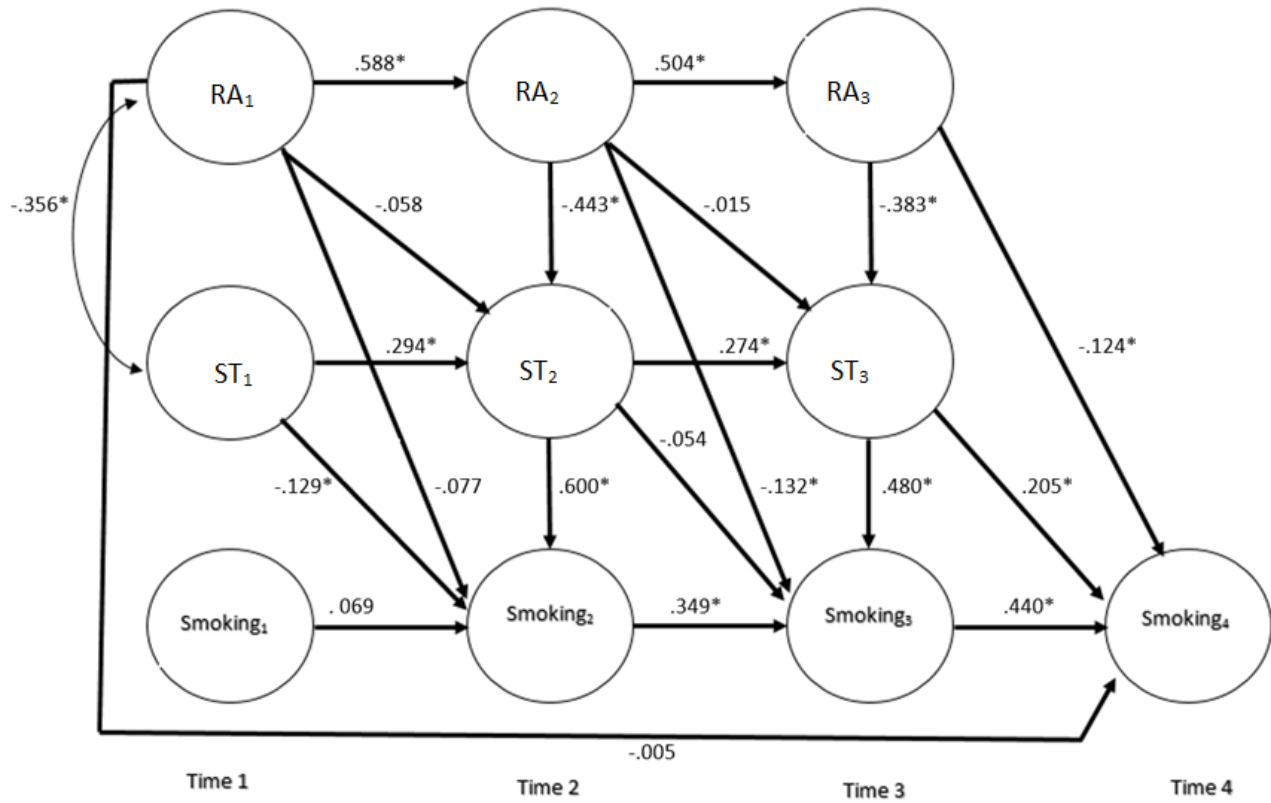
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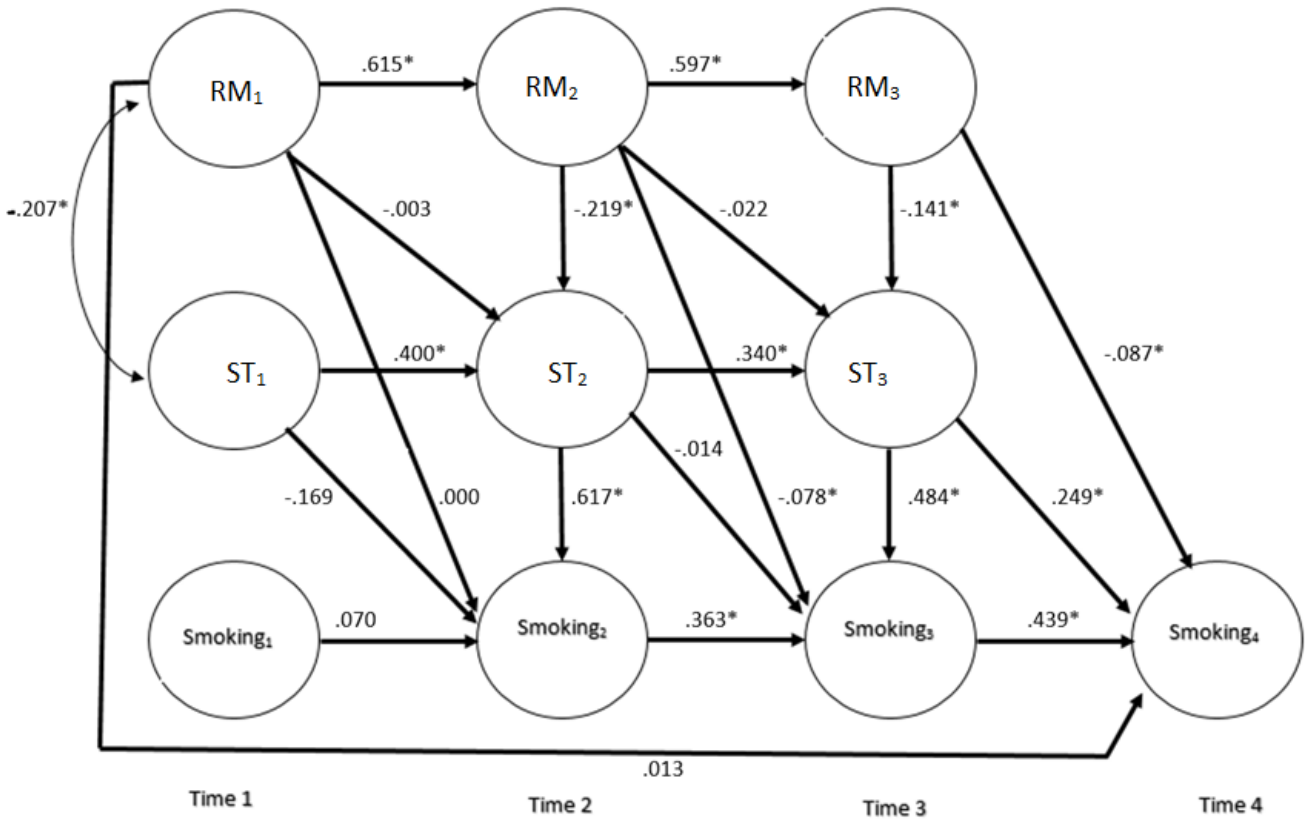
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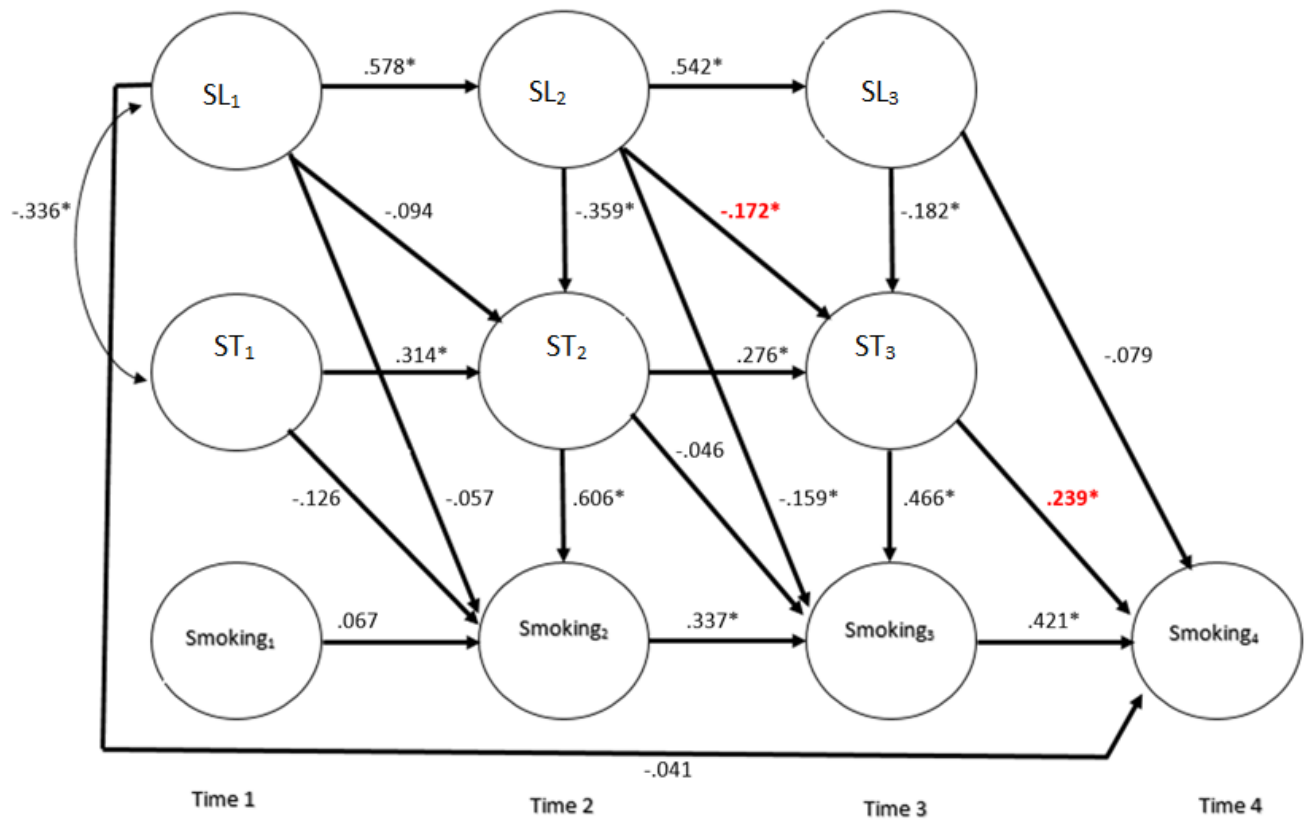
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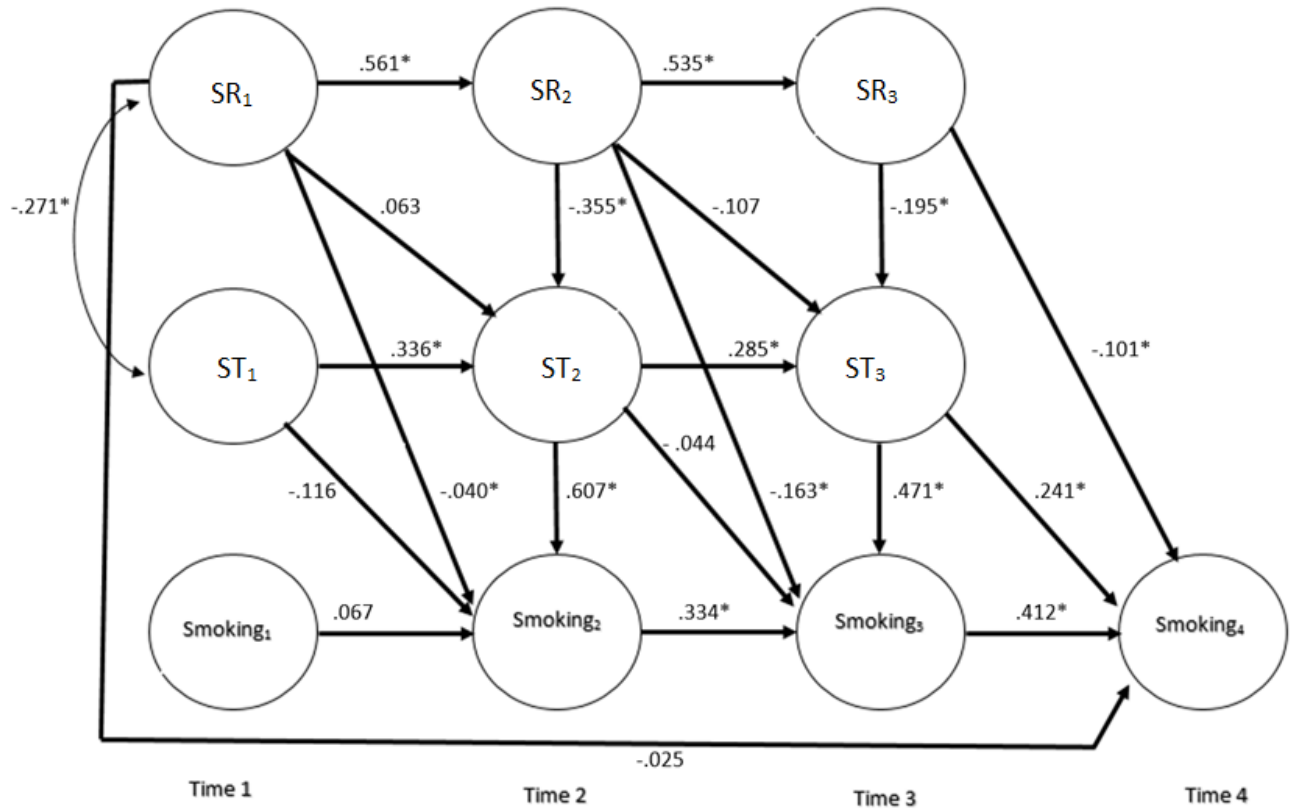
Single Mediator Model of the Situational Temptations of smoking and Refusal Assertiveness



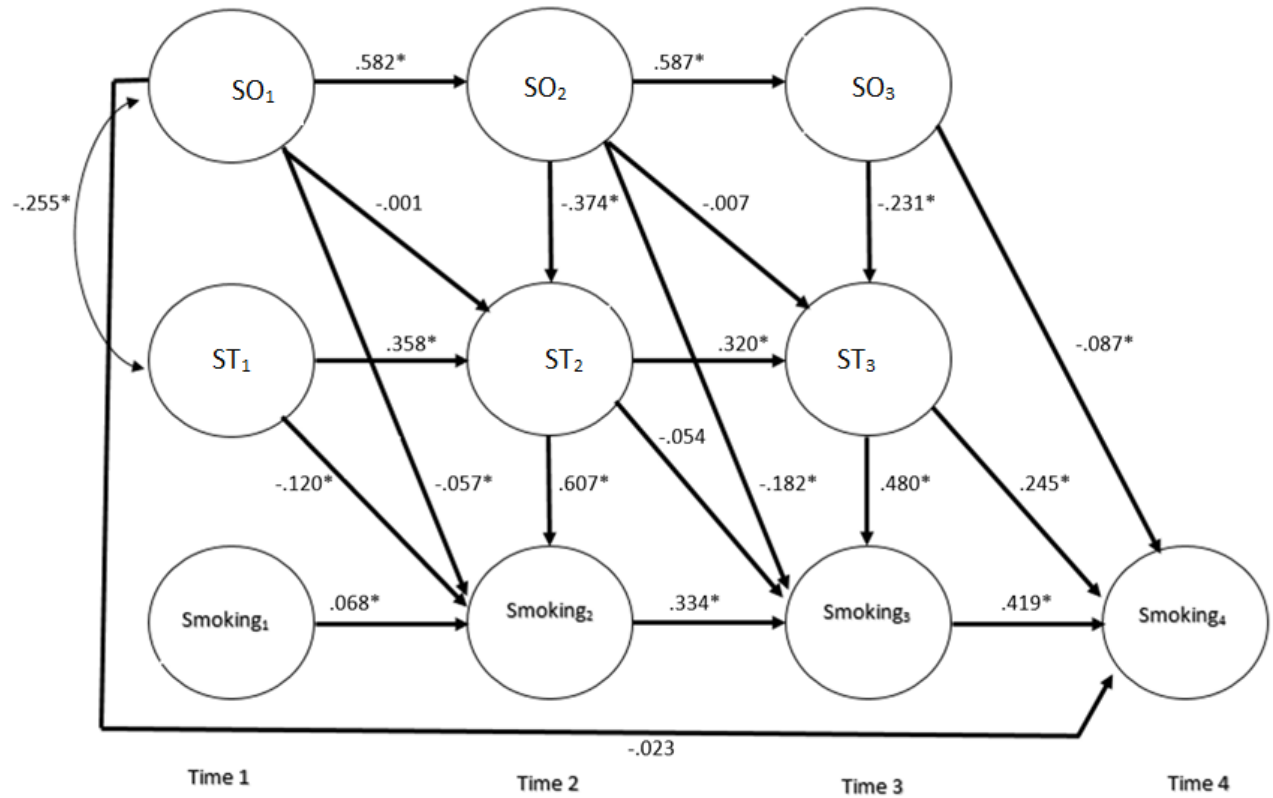
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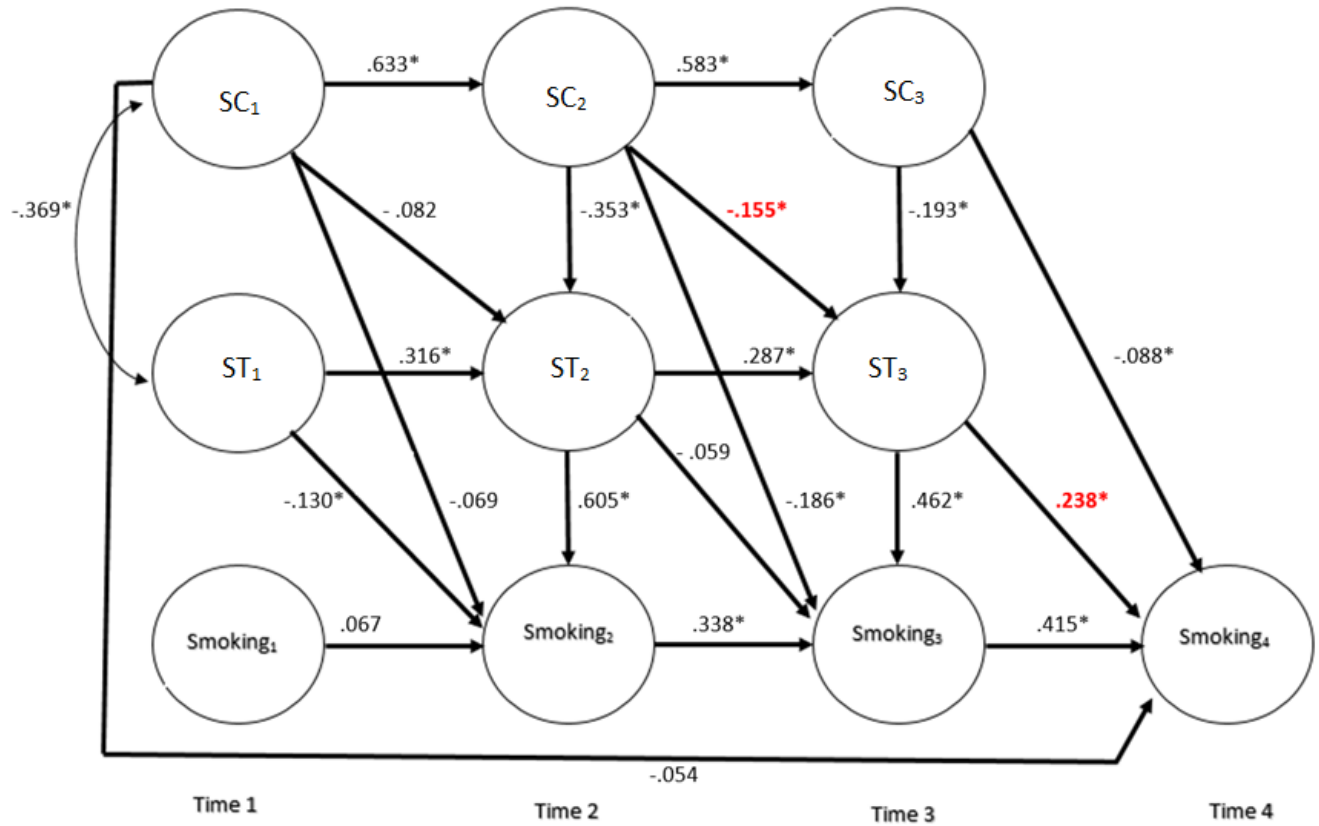
Single Mediator Model of the Situational Temptations of smoking and Self-Liberation



Single Mediator Model of the Situational Temptations of smoking and Self-Reevaluation



Single Mediator Model of the Situational Temptations of smoking and Social Liberation



Single Mediator Model of the Situational Temptations of smoking and Stimulus Control

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