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## AN EXAMINATION OF SEQUENTIAL AND SIMULTANEOUS BEHAVIOR CHANGE WITHIN TWO MULTIPLE HEALTH BEHAVIOR CHANGE CONDITIONS

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AN EXAMINATION OF SEQUENTIAL AND SIMULTANEOUS  
BEHAVIOR CHANGE WITHIN TWO MULTIPLE HEALTH BEHAVIOR  
CHANGE CONDITIONS

BY

EVA-MOLLY PETITTO DUNBAR

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF  
MASTER OF ARTS  
IN  
CLINICAL PSYCHOLOGY

UNIVERSITY OF RHODE ISLAND

2015

MASTER OF ARTS IN CLINICAL PSYCHOLOGY THESIS  
OF  
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2015

## ABSTRACT

Research on the simultaneous treatment of multiple health risk behaviors has grown in recent years in the field of multiple health behavior change. Yet there is little research on how people change behaviors that are treated simultaneously. To help predict behavior change, and, thus, to prevent chronic illness on a population level, it is necessary to advance understanding of the patterns of behavior change. The present study examined participants with multiple health risk behaviors who have changed pairs of behaviors over time. Data were analyzed from four randomized controlled trials using Transtheoretical Model (TTM) tailored interventions and comparison groups ( $N = 1,277$  weight management study;  $N = 9,461$  cancer prevention study). Patterns of sequential (one behavior in a pair changed in a particular period, followed by the other) and simultaneous (both behaviors in a pair changed in the same time period and sustained that change) behavior change across four time points (baseline, 6, 12, and 24 months) were identified for each behavior pair. Ten different patterns of change were found and cohered into three distinct groupings of change: (1) overall simultaneous vs. sequential patterns, (2) simultaneous versus sequential patterns during the first phase of the study (first 12 months) and the second phase (12-24 months) of the study, and (3) simultaneous versus sequential patterns for those who recycled behaviors during the course of the study (over a 24 month time period). A series of chi-square analyses were conducted to examine differences between treatment and control group participants, participants with homogeneous and heterogeneous behaviors, and participants in different Stages of Change across each behavior pair within the three distinct groupings. Results are presented regarding the

proportions of individuals who changed both behaviors in a pair sequentially or simultaneously, whether treatment and control groups followed different patterns of change, whether dissimilar behavior pairs (i.e., smoking, sun, diet) follow different patterns of change than similar behaviors (i.e., physical activity, diet, and emotional eating), and whether baseline Stage of Change impacts behavior change patterns. The findings provide a new window into the process of behavior change, illuminating a new way in which to understand the underlying mechanisms of behavior change. The discovery that the majority of behavior change is sequential rather than simultaneous advances the field of multiple health behavior change in a novel way; even when behaviors are treated simultaneously they are more likely to change sequentially.

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The present study is a secondary data analysis of data obtained from four randomized trials involving multiple health behavior interventions and comparison groups (#H9900-005, H9394-040, H9495-091, Principle Investigator, Prochaska). As this study was a secondary data analysis, there was no potential risk for the participants of the original study, thus, an exemption was granted by the Institutional Review Board (IRB) for this project.

## **PREFACE**

This thesis was written in manuscript format, using APA style.

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## MANUSCRIPT

### **An Examination of Sequential and Simultaneous Behavior Change within Two Multiple Health Behavior Change Conditions**

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## INTRODUCTION

Multiple Health Behavior Change (MHBC) is especially important in our disease susceptible society, as populations with co-occurring multiple health behavior risks suffer greater morbidity, disability, and premature mortality (Prochaska, 2008). Modifiable behaviors are a key factor in health promotion, disease prevention and management of heart disease, stroke, cancer, and diabetes, which are the most prevalent, and costly to the U.S. health system. The most common causes of chronic disease are lack of physical activity, poor nutrition, tobacco use, and excessive alcohol consumption (Centers for Disease Control and Prevention [CDC], 2012). Multiple risk factors have a negative synergistic influence on health, where the combinations of these risk factors are more harmful than the impact of the individual effects of the risk factor alone, thus indicating that the effects of health risk factors are multiplicative rather than additive (Breslow & Enstorm, 1980). It is for this reason that MHBC research—the understanding of how co-occurring behaviors change and the design of more effective MHBC interventions—will have a greater impact on public health than single behavior interventions.

Within MHBC, a growing amount of research exists on the simultaneous treatment of multiple health risk behaviors, yet there is little research on such behavior change. Do simultaneously treated behaviors change simultaneously or sequentially? The overarching goal is to identify the patterns of simultaneous and sequential behavior change among participants who have changed pairs of

behaviors over time. Better understanding of sequential versus simultaneous behavior change may help guide more effective multiple health behavior interventions

To advance the understanding of the patterns of multiple behavior change the systematic order in which individuals change as a result of simultaneous multiple health behavior interventions were analyzed. When paired health behaviors are targeted for change, both of the behaviors may be changing at the same time, where the change is sustained (simultaneous) or, one behavior in the pair may be changing first, followed by the other (sequential). Most MHBC research has focused on changes in populations. Recent research has focused on studying MHBC within individuals, beginning with pairs of behaviors as the fundamental unit of MHBC. There are identified emerging properties of change that cannot be predicted from MHBC in populations. Coaction is an example of where individuals change one behavior in a pair and are more likely to change the second behavior. This is in contrast to individuals who do not change the first behavior. But coaction is a phenomenon that occurs primarily in treated individuals, indicating it may not be a natural process. However, research has not yet determined which behavior changed first and which was impacted next, or whether both behaviors changed in the same period of time, such as during the intervention period. When examining such patterns of behavior change, knowledge of the success patterns of different pairs of behavior, may represent different mechanisms of change that could have significant predictive power for future interventions.

Studies of individuals with multiple co-occurring health risk behaviors have identified other emerging phenomenon of behaviors changing over time; with paired action or with singular action. In paired action, the individual changes over time on both behaviors. In singular action, individuals change over time on only one of the behaviors within the pair (Prochaska et al., unpublished study). In a recent comparative study of behaviors changed via paired action versus singular action (Prochaska et al., unpublished study), paired action yielded the highest number of behaviors changed over singular action, only in treatment groups with positively linked homogeneous behaviors (e.g., energy balance behaviors). With all other groups, there was a dominant tendency for individuals to change one behavior in a pair, rather than both. The authors further demonstrated that the Transtheoretical Model (TTM), which incorporates an individual's readiness for change (Prochaska & DiClemente, 1983), may impact this outcome. It has been found that the TTM treatment intervention seemed to decrease this singular action trend by 50% compared to controls with negatively linked pairs of behaviors. Conversely the pattern was reversed in individuals with positively linked pairs of behaviors (Prochaska et al., unpublished study).

The specific aim of the study reported in this thesis is to identify individuals who change simultaneously and those who change sequentially. In addition, the present study seeks to identify predictors of simultaneous and sequential change. These relationships will be analyzed on pairs of positively linked homogeneous behaviors (energy balance behaviors) and on pairs of

negatively linked heterogeneous behaviors (addictive, energy balance, and adherence- related behaviors).

Previous studies have confirmed the consistency of four effects (stage of change, severity, treatment, and effort) as predictors of long-term health risk behavior change in the context of changes in behaviors studied separately (Blissmer, et al., 2010). However, these studies have not examined whether these effects are predictors of simultaneous versus sequential behavior changes. Blissmer et al. (2010) found consistent treatment, stage of change, severity, and effort effects across a range of behavior changes in long-term health risk behavior change, specifically in smoking, diet, and sun exposure. These four effects, when assessed at baseline, were found to be related to changes in behaviors that were assessed separately at 24 months.

*Significance:* The study of how clusters of behaviors change in interventions targeting MHBC over time is particularly important in chronic disease prevention, such as cancer, obesity, and diabetes (Noar, Benac, Harris, 2007). A major strategy of early intervention paradigms involved targeting individuals at high risk for chronic disease and focusing on separate health risk behaviors, often without considering readiness for change. A more recent and prevailing paradigm focuses on multiple health behavior change (MHBC), with nuanced and detailed focus on stage- matched interventions (Prochaska, Spring, & Nigg, 2008). This more recent paradigm not only targets individuals at high risk for illness, but also integrates a broad strategy that targets entire populations. As a result, public health concerns have shifted from focusing on individual



intervention programs to population- level intervention programs. The call for research on multiple health behavior interventions, including those behaviors that may influence one another and simultaneously change, was declared to be one of NIH's top priorities (Prochaska, Spring, & Nigg, 2008).

Energy balance behaviors are behaviors that are homogeneous (similar in function) and include diet, exercise, and emotional eating. These behaviors are modifiable, but if not targeted may lead to various health consequences in populations at high risk for the health consequences of obesity (Johnson et al., 2008). Indeed, they are behaviors that are essential to obesity prevention and weight management. For example, poor diet and physical inactivity have been shown to increase risks of diabetes, cardiovascular disease and cancer (USDHHS, 1996). Homogeneous behaviors have also been found to be positively linked, whereupon observed linked behavior change was greater than what was predicted if behaviors change separately and independently (Prochaska et al., unpublished study).

Healthy eating for weight control entails reducing caloric intake by 500 calories per day and total fat intake to less than 30% of calories, regular exercise is defined as 30 minutes of moderate exercise on at least 5 days a week, and treatment of emotional eating involves managing emotions without eating (Johnson et al., 2008). Several researchers have demonstrated that targeting clusters or pairs of behaviors can be potent, for example, in multiple health behavior interventions that target dietary intake and physical activity (Appel et al., 2011). Remarkably, the mechanisms underlying change within these pairs are

largely unknown. An important insight into such mechanisms could be revealed from studies on the effects that each behavior in the pair may hold, as a result of the timing of each behavior's change.

Heterogeneous pairs of behaviors include different types of behaviors (e.g., addictive, energy balance, and adherence- related behaviors). This study will include smoking, diet, and sun. At times, these heterogeneous behaviors have been referred to as cancer- prevention behaviors. However, it may be inaccurate to refer solely to the heterogeneous behaviors as cancer- related behaviors, since homogeneous behaviors are also related to the development of cancer. Therefore, the present study will refer to mixed cancer prevention behaviors as heterogeneous behaviors.

Coaction is another phenomenon of multiple health behavior change in sets of homogeneous and heterogeneous behaviors. Coaction is a form of synergy whereupon changes on one behavior in a pair increase the probability of changes on the other behavior in the pair (Johnson, Paiva, Mauriello, Prochaska, Redding, & Velicer, 2013). Coaction has been found to be greater in treatment groups. Further, studies on coaction have focused on behaviors in pairs in at-risk individuals at baseline assuming that these behaviors co-occur, and examined how these pairs of behaviors change together or independently at follow up within treatment or control groups (Johnson et al., 2013). In a separate study, Paiva et al. (2012) found that with TTM-based Multiple Health Behavior interventions for smoking, dietary fat reduction, and sun exposure, individuals in the control group were less likely than those in the treatment group to take action on a second

behavior if they took action on one. In earlier studies of heterogeneous behaviors, such odds ratios have been observed as well. This pattern has also been found in homogeneous behaviors. Johnson et al. (2008), demonstrated the ability that TTM-based tailored feedback has in improving healthy eating, exercise, managing emotional distress, and weight on a population basis. This study looked at coaction comparisons in energy balance behaviors in treatment and control groups in a sample of overweight and obese adults who were treated for exercise, diet and emotional eating. They found that individuals who were treated had consistently higher coaction than control groups. Here both heterogeneous behaviors and homogeneous behaviors have been found to have coaction be consistently higher in the treatment group than the control group. Furthermore, coaction has been found to be higher when the behavior pairs are homogeneous compared to heterogeneous.

Most noteworthy, there is a major gap in knowledge about patterns of behavior change (simultaneous vs. sequential) in treated pairs of behaviors where both behaviors are changed at follow-up—what patterns were followed at what frequencies and which patterns were followed more by treatment and controls and homogeneous vs. heterogeneous behaviors. Such knowledge could have predictive power in the future development and tailoring of multiple health behavior interventions. To advance our understanding of the drivers of paired action, the present study will examine whether there is simultaneous or sequential change in multiple behavior change within pairs of behaviors, which, at final follow-up, have both changed. Predictors of simultaneous and sequential behavior

change will be compared across treatment and control groups, type of behavior pair, and Stage of Change.

## METHODS

This research involves secondary data analysis of data from four randomized trials involving simultaneous multiple health behavior interventions and control groups. This study investigates whether at-risk multiple health behaviors changed in a simultaneous or a sequential way. What is novel in this study is the analysis of the time points at which these changes occur. This project will 1) examine the percentages of individuals who change both behaviors in a pair sequentially or simultaneously, 2) examine Stage of Change and treatment as predictors of simultaneous vs. sequential patterns of behavior change, and 3) examine whether the heterogeneous behavior pairs (smoking, sun, diet) follow a different pattern of change than the homogenous behaviors (physical activity, diet, and emotional eating). Exploring the order in which behavior changes occur will provide new insight into multiple health behavior change within individuals.

### *Participants*

In study 1, a national sample of 1,277 overweight and moderately obese adults [mean age=45.37; mean BMI=30.75; 47.6% female, 79.1% White, 6.5% Black, 7.0% Hispanic, and 7.2% other] was randomized to receive either usual care or fully tailored TTM feedback reports for up to three risk behaviors based on the national guidelines at the time: healthy eating (reducing caloric intake by 500 calories per day and total fat intake to less than 30% of calories), regular exercise (30 min of moderate exercise on at least five days a week), and managing emotions without eating. Intervention group participants received four fully tailored reports (baseline, 3, 6 and 9 months) that provided feedback on Stage of

Change, decisional balance, self-efficacy, and up to six stage-matched processes, and a stage-matched manual addressing energy balance behaviors and fruit and vegetable consumption. Control participants completed assessments at baseline and 6 months. Follow-up assessments were conducted with all participants at 12 and 24 months. A total of 1,200 participants were at risk for two or more of the behaviors (exercise, healthy eating, emotional eating and FV) at baseline (Johnson et al., 2008).

Sample 2 pooled treatment and control participants from three separate randomized controlled trials from a National Cancer Institute Center grant which used common interventions, procedures, measures, and assessment schedules, in trials that recruited parents (Prochaska et al., 2004), primary care patients (Prochaska et al., 2005), and employees (Velicer et al., 2004) who were at risk for at least one targeted behavior (smoking, diet, or sun protection). The demographics and stage distributions for the combined treatment and control groups ( $N=9,461$ ) were comparable, so it was reasonable to pool the data from all three trials. The majority were married, non-Hispanic Caucasian females with a mean age of 44 years. The total group of participants was least prepared to change smoking (21.8% in preparation), then diet (33.0% in preparation), and most prepared to change sun protection (43.9% in preparation). Assessments were conducted at baseline, 12 and 24 months. Participants were randomly assigned to the intervention and control group.

The intervention group received fully tailored print TTM CTIs mailed to their homes for any of the three targeted behaviors that they were at risk for (e.g.,

only smokers got feedback on smoking) at baseline, 6 and 12 months. In addition to the CTIs, participants in the treatment group also received a stage-matched multiple behavior change manual at baseline that presented principles for progressing from one stage to the next and how to apply these change principles across multiple behaviors. A total of 5,517 participants at baseline had at least two of the three risk behaviors (smoking, diet, and sun protection). All primary studies were approved by the Institutional Review Boards at the University of Rhode Island (study 2) and Pro-Change Behavior Systems, Inc. (study 1), respectively.

### *Measures*

#### *Demographics*

The available demographics for these five baseline samples provided information on gender, age, race, education, ethnicity, health status, and marital status.

#### *Stages of Change*

Behavior change is measured by the individual's progression through the five Stages of Change on both behaviors in the pair of simultaneously treated at risk behaviors. 1= Precontemplation (PC- no intention to change behavior in the next 6 months), 2= Contemplation (C- intending to change in the next six months), 3= Preparation (PR- intending to change in the next thirty days), 4= Action, (A- individual has modified the problem behavior), 5= Maintenance (M- individual has maintained behavior change for at least 6 months). The stages will be examined for both the behaviors in the pair (e.g, the individual is in precontemplation for both the behaviors in the pair).

### *Treatment*

Treatment is assessed as to whether or not the participant received the TTM-tailored expert system or the comparison group. Participants who received the TTM-tailored expert system (treatment) received the intervention during the first 12 months of the study, which is the time during which the treatment and control groups were treated differently. In the second phase of the study (12-24 months), both the treatment and control groups were not receiving an intervention.

### *Hypotheses and Planned Analyses*

Hypothesis 1: Patterns of sequential and simultaneous behavior change will occur across four time points (0, 6, 12, and 24 months) for each behavior pair. Ten different patterns of change are hypothesized. These 10 patterns of change will be collapsed in three different ways to examine more specific behavior change questions. The three distinct groupings of change are: 1) overall simultaneous patterns vs. sequential patterns, 2) simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months), and 3) simultaneous vs. sequential patterns for those who recycled behaviors after relapsing during the course of the study.

*Analysis 1:* Frequencies and other descriptive analyses were conducted to assign participants to different patterns of behavior change for each behavior pair. The different patterns were then combined to form the three grouping variables to test the following hypotheses.



Hypothesis 2: Since simultaneous treatment produces more MHBC, it is expected that more participants in the treatment group will be in the simultaneous pattern of behavior change within each of the three distinct groupings being examined (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

*Analysis 2:* A series of chi-square analyses were conducted to examine the differences in proportions of treatment group participants compared to control group participants across each behavior pair within the three distinct groupings.

Hypothesis 3: Given that simultaneous treatment of homogeneous pairs leads to greater paired action than negatively linked pairs, it is expected that more participants will be in the simultaneous pattern of multiple behavior change when the behavior pairs are homogenous (physical activity, diet, and emotional eating) compared to heterogeneous (smoking, sun, and diet) for the three distinct groupings (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

*Analysis 3:* A series of chi-square analyses were conducted to examine the differences in proportions of participants in each of the patterns of multiple behavior change across homogenous and heterogeneous behavior pairs within the three distinct groupings.

Hypothesis 4. It is expected that participants who are in Preparation at baseline for both behaviors in a pair will more likely be in the simultaneous patterns of multiple behavior change than participants in the earlier Stages of Change at Baseline (PC/C or a combination of PC/C and Preparation) within the three distinct groupings (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

*Analysis 4.* A series of chi-square analyses were conducted to examine the differences in proportions of participants in each of the patterns of multiple behavior change across baseline Stage of Change within the three distinct groupings.

## RESULTS

H1: Patterns of sequential and simultaneous behavior change across four time points (0, 6, 12, and 24 months respectively) were examined for each behavior pair. Ten different patterns of change were examined (see figure 1). These 10 patterns of change were collapsed in three different ways to examine more specific behavior change questions. The three distinct groupings of change are: 1) overall simultaneous patterns vs. sequential patterns, 2) simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months), and 3) simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study.

Frequency counts of the order of behavior change were conducted to assign participants to different patterns of behavior change: This was tabulated for each behavior pair (smoking and sun, smoking and diet, diet and sun, physical activity and diet, physical activity and emotional eating, and emotional eating and diet). Ten different paths of change were found and the resulting frequencies are presented in Table 1.

Results revealed that, as hypothesized, one half of the paths were larger and each contained roughly 15% of participants within each of the paths (mean number of participants per path = 36,  $SD = 5.1$ ). The other half were smaller and contained approximately 5% of participants in each of them ( $M = 13$ ,  $SD = 4.8$ ). Four of the five paths containing the most individuals were sequential, and four of the five smallest paths were simultaneous.

Another result relates to those of who relapsed on at least one behavior during the course of the study but eventually changed both by the end of the study. We label them recyclers, as this term is more suitable, since, in the end, they changed both behaviors even though they recycled at least one during the course of the study. Four of the 10 paths contained individuals who recycled behaviors. Recyclers are individuals who moved from being at risk for two behaviors, to no longer being at risk for one or both of these behaviors. However, they then go back to being at risk for one or both of the behaviors during the course of the study (24 months). Thus by the end of the study they have changed both behaviors.

The ten patterns were then collapsed into three distinct groupings based on their patterns of change:

**Overall Simultaneous vs. Sequential Patterns (24 months).** Forty-two percent of participants were in the simultaneous patterns of behavior change, and 58% of participants were in the sequential patterns of behavior change (see Table 2).

**Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and the Second Phase of the Study (12-24 months).** 24.1% of participants were in the simultaneous patterns of behavior change during the first phase of the study (first 12 months), and 15.9% of participants were in the sequential patterns of behavior change during the first phase. Additionally, 11.4% of participants were in the simultaneous patterns of behavior change during the second phase of the study (12-24 months), and 48.6%

of participants were in the sequential patterns of behavior change during the second phase (see Table 3).

**Simultaneous vs. Sequential Patterns for those who Recycled Behaviors During the Course of the Study (24 months).** Among participants who recycled behaviors during the course of the study 58.8% were in the sequential patterns of behavior change and 41.2% were in the simultaneous patterns of behavior change (see Table 4).

H 2: Since simultaneous treatment produces more MHBC, it is expected that more participants in the treatment group will be in the simultaneous pattern of behavior change within each of the three distinct groupings being examined (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

A series of chi-square analyses were conducted to examine the differences in proportions of treatment group participants compared to control group participants across each behavior pair within the three distinct groupings.

**Overall Simultaneous vs. Sequential Patterns (24 months).** A chi-square test was performed and a significant relationship was found between patterns of behavior change (simultaneous vs. sequential patterns of behavior change) and group (treatment vs. control),  $\chi^2(1, N = 245) = 7.79, p < .01$ . Within the treatment group, 35.6% were in the simultaneous patterns of behavior change,

and 64.4% of participants were in the sequential patterns of behavior change. Within the control group, 54.1% were in the simultaneous patterns of behavior change, and 45.9% of participants were in the sequential patterns of behavior change (see Table 5).

**Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and the Second Phase of the Study (12-24 months).** A chi-square test was performed and a significant relationship was found between patterns of behavior change during the first phase of the study (first 12 months of the study; simultaneous vs. sequential patterns of behavior change) and group (treatment vs. control),  $\chi^2(3, N = 245) = 16.22, p = .001$ . Within the treatment group, 21.3% were in the simultaneous patterns of behavior change during the first phase of the study, and 21.9% of participants were in the sequential patterns of behavior change during the first phase. At the end of the second phase of the study (at final follow-up), 8.1% of participants who were in the treatment group were in the simultaneous patterns of behavior change, and 48.8% were in the sequential patterns of behavior change. Within the control group, 29.4% were in the simultaneous patterns of behavior change during the first phase of the study, and 4.7% of participants were in the sequential patterns of behavior change during the first phase. At the end of the second phase of the study, 17.6% of participants who were in control group were in the simultaneous patterns of behavior change, and 48.2% were in the sequential patterns of behavior change (see Table 6).

**Simultaneous vs. Sequential Patterns for those who Recycled behaviors During the Course of the Study (24 months).** A chi-square test was

performed revealing no significant difference between patterns of behavior change (simultaneous vs. sequential patterns of behavior change) among those who recycled behaviors during the course of the study and group (treatment vs. control),  $\chi^2(1, N = 68) = .01, p > .05$ . Within the treatment group among those who recycled behaviors during the course of the study, 41.9% were in the simultaneous patterns of behavior change, and 58.1% of participants were in the sequential patterns of behavior change. Within the control group among those who recycled behaviors during the course of the study, 40.5% were in the simultaneous patterns of behavior change, and 59.5% of participants were in the sequential patterns of behavior change (see Table 7).

H3: Given that simultaneous treatment of homogeneous pairs leads to greater paired action than negatively linked pairs, it is expected that more participants will be in the simultaneous pattern of multiple behavior change when the behavior pairs are homogenous (physical activity, diet, and emotional eating) compared to heterogeneous (smoking, sun, and diet) for the three distinct groupings (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

A series of chi-square analyses were conducted to examine the differences in proportions of participants in each of the patterns of multiple behavior change

across homogenous and heterogeneous behavior pairs within the three distinct groupings.

**Overall Simultaneous vs. Sequential Patterns (24 months).** A chi-square test was performed and a significant relationship was found between patterns of behavior change (simultaneous vs. sequential patterns of behavior change) and behavior pair (homogeneous vs. heterogeneous),  $\chi^2 (1, N = 245) = 4.26, p < .05$ . Within participants with homogeneous behavior pairs, 51.2% were in the simultaneous patterns of behavior change, and 48.8% of participants were in the sequential patterns of behavior change. Within participants with heterogeneous behavior pairs, 37.4% were in the simultaneous patterns of behavior change, and 62.6% of participants were in the sequential patterns of behavior change (see Table 8).

**Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and the Second Phase of the Study (12-24 months).** A chi-square test was performed revealing no significant differences between patterns of behavior change during the first phase of the study (first 12 months of the study; simultaneous vs. sequential patterns of behavior change) and behavior pair (homogeneous vs. heterogeneous),  $\chi^2 (3, N = 245) = 2.41, p > .05$ . Within participants with homogeneous behavior pairs, 29.3% were in the simultaneous patterns of behavior change during the first phase of the study, and 15.9% of participants were in the sequential patterns of behavior change during the first phase. At the end of the second phase of the study (at final follow-up), 8.5% of participants with homogeneous behavior pairs were in the simultaneous patterns



of behavior change, and 46.3% were in the sequential patterns of behavior change. Within participants with heterogeneous behavior pairs, 21.5% were in the simultaneous patterns of behavior change, and 16% of participants were in the sequential patterns of behavior change. At the end of the second phase of the study, 12.9% of participants with heterogeneous behavior pairs were in the simultaneous patterns of behavior change, and 49.7% were in the sequential patterns of behavior change. Here, independent of the type of behavior pair, more individuals changed in the second phase of the study, and were in the sequential patterns of behavior change (see Table 9).

#### **Simultaneous vs. Sequential Patterns for those who Recycled**

**Behaviors During the Course of the Study (24 months).** A chi-square test was performed and a significant relationship was found between patterns of behavior change (simultaneous vs. sequential) among those who recycled behaviors during the course of the study and behavior pair (homogeneous vs. heterogeneous),  $\chi^2 (1, N = 68) = 4.02, p < .05$ . Within participants with homogeneous behavior pairs who recycled behaviors, 70% were in the simultaneous patterns of behavior change, and 30% of participants were in the sequential patterns of behavior change. Within participants with heterogeneous behavior pairs among those who recycled behaviors, 36.2% were in the simultaneous patterns of behavior change, and 63.8% were in the sequential patterns of behavior change (see Table 10).

H4: It is expected that participants who are in Preparation at baseline for both behaviors in a pair will more likely be in the simultaneous patterns of

multiple behavior change than participants in the earlier Stages of Change at Baseline (PC/C or a combination of PC/C and Preparation) within the three distinct groupings (overall simultaneous patterns vs. sequential patterns; simultaneous vs. sequential patterns during the first phase of the study (first 12 months of the study), and the second phase of the study (12-24 months); simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study).

A series of chi-square analyses were conducted to examine the differences in proportions of participants in each of the patterns of multiple behavior change across baseline Stage of Change within the three distinct groupings.

**Overall Simultaneous vs. Sequential Patterns (24 months).** A chi-square test revealed no significant differences between simultaneous and sequential patterns of behavior change and baseline Stage of Change (Preparation for both behaviors vs. PC/C or a combination of PC/C and Preparation),  $\chi^2(1, N = 245) = 0, p > .05$ . Within participants who were in Preparation at baseline for both behaviors in a pair, 42% were in the simultaneous patterns of behavior change, and 58% of participants were in the sequential patterns of behavior change. Within participants who were in the earlier Stages of Change at baseline, 42.1% were in the simultaneous patterns of behavior change, and 57.9% of participants were in the sequential patterns of behavior change (see Table 11).

**Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and the Second Phase of the Study (12-24 months).** A

chi-square test was performed revealing no significant differences between patterns of behavior change during the first phase of the study (first 12 months of the study; simultaneous vs. sequential patterns of behavior change) and baseline Stage of Change (Preparation for both behaviors vs. PC/C or a combination of PC/C and Preparation),  $\chi^2(3, N = 245) = 1.34, p > .05$ . Within participants who were in Preparation at baseline for both behaviors in a pair, 24% were in the simultaneous patterns of behavior change during treatment, and 18% of participants were in the sequential patterns of behavior change during the first phase of the study. After the second phase of the study (at final follow-up), nine percent of participants who were in Preparation at baseline for both behaviors in a pair were in the simultaneous patterns of behavior change, and 49% were in the sequential patterns of behavior change. Within participants who were in the earlier Stages of Change at baseline, 24.1% were in the simultaneous patterns of behavior change during the first phase of the study, and 14.5% of participants were in the sequential patterns of behavior change during the first phase of the study. After treatment, 13.1% of participants who were in the earlier Stages of Change at baseline were in the simultaneous patterns of behavior change, and 48.3% were in the sequential patterns of behavior change (see Table 12).

**Simultaneous vs. Sequential Patterns for those who Recycled behaviors During the Course of the Study (24 months).** A chi-square test was performed revealing no significant differences between patterns of behavior change (simultaneous vs. sequential patterns) among those who recycled behaviors during the course of the study and baseline Stage of Change

(Preparation for both behaviors vs. PC/C or a combination of PC/C and Preparation),  $\chi^2 (1, N = 68) = .04, p > .05$ . Among those participants who were in Preparation at baseline (involving both behaviors in a pair), and who then recycled behaviors during the course of the study, 42.9% were in the simultaneous patterns of behavior change, and 57.1% were in the sequential patterns of behavior change. Within participants who were in the earlier Stages of Change at baseline among those who recycled behaviors during the course of the study, 40.4% were in the simultaneous patterns of behavior change, and 59.6% of participants were in the sequential patterns of behavior change (see Table 13).

## DISCUSSION

Traditionally, simultaneous treatment has been equated with simultaneous behavior change. However, for the first-time, the results in this thesis shed light on the fundamental question of how simultaneous and sequential patterns of behaviors change. In particular, these results reveal that overall, independent of behavior types, simultaneous treatment is more frequently associated with sequential behavior change than with simultaneous behavior change. This effect was obtained in those individuals who changed both of their at-risk behaviors by the end of the study. By analyzing treatment and control groups, type of behavior pairs, and Stage of Change over periods of time, previously unseen patterns in behavior change were revealed. These results provide a deeper understanding of the mechanisms underlying patterns of behavior change with important implications for MHBC interventions and new ways of assessing their impacts.

*Patterns of Behavior Change Groupings.* The results reveal that four of the five paths with larger groups were sequential, while the opposite was seen for the smaller groups. The results demonstrate that, overall, individuals with at-risk multiple health behaviors tend to more frequently change in a sequential manner rather than in a simultaneous manner (58 percent vs. 42 percent). This effect occurred for both treatment and control groups and was examined in individuals who changed both at risk behaviors (referred to as paired action) at final follow-up (24 months after the study began). Among the participants who changed during the first phase of the study (first 12 months), participants more often changed in a simultaneous manner (24.1 percent) rather than a sequential manner

(15.9 percent). Surprisingly, more participants changed in the second phase of the study, and changed in a sequential manner (48.6 percent; 11.4% of the participants were in the simultaneous patterns of behavior change during the second phase of the study). The results found that during the first phase of the study, simultaneous behavior change is more common, whereas, the dominant pattern at the end of the second phase of the study is sequential behavior change.

*Treatment vs. Control Group.* It was originally hypothesized that since simultaneous treatment produces more MHBC, more participants in the treatment group (receiving the TTM intervention) would be in the simultaneous patterns of behavior change within each of the three distinct groupings examined. However, results reveal that, overall, a greater percentage of individuals in the treatment group were in the sequential patterns of behavior change (64.4 percent), while a greater percentage of individuals in the control group were in the simultaneous patterns of behavior change (54.1 percent). In addition, a greater proportion of individuals in both the treatment and control groups changed in the second phase of the study in a sequential manner (48.8% and 48.2% respectively).

When discussing the traditional assumption that simultaneous treatment leads to simultaneous change, our results reveal that this is not the case. When examining sequential behavior change within the context of the treatment intervention, which employs the TTM, the TTM takes into account an individual's readiness to change. When using the TTM to simultaneously treat multiple health risk behaviors, although it is simultaneously treating the behaviors, it implies that the individual may change their behaviors when they are

ready. Thus, an individual may change one behavior first, and then follow by changing the other behavior. This signifies that the process of the TTM may allow for more sequential behavior change. In contrast, the action paradigm still dominates individuals' mindsets. Individuals in the control group may still maintain the mindset that they must change both behaviors at the same time, thus leading to more simultaneous behavior change. The TTM may actually be encouraging sequential behavior change, in which one is learning how to change during treatment and can apply these changes after treatment. Specifically, the individual may be learning how to progress through the stages during treatment and be further along in the Stages of Change at 12 months (end of TTM intervention), which may be related to paired action at 24 months (changing both behaviors in a pair at the end of the study). If behavior change had only been assessed at 12 months, then an erroneous conclusion would have been reached—specifically, it would have been falsely concluded that the individuals who had only changed one behavior at this time point had failed at changing both behaviors.

Furthermore, this process of sequential behavior change may be understood through coaction. Coaction has never before been addressed in the context of whether both behaviors follow simultaneous vs. sequential behavior change. Here, coaction, which has been found to be enhanced by treatment, may explain the greater sequential behavior change within the treatment group. Within paired action (changes in both behaviors in a pair), coaction may be associated with greater sequential behavior changed when assessed over time. Taking

effective action on one behavior at an earlier time point (6 months or 12 at the end of the first phase of the study) may be related to taking action on a second behavior at a later time point (12 months or 24 months). Here, success with one behavior at the end of the first phase of the study may have increased self-efficacy or motivation to change the other behavior following the first phase of the study.

*Homogeneous vs. Heterogeneous Pairs of Behaviors.* It was expected that more participants would follow the simultaneous patterns of multiple behavior change when the behavior pairs are homogenous (physical activity, diet, and emotional eating) compared to heterogeneous (smoking, sun, and diet). This expectation would hold for the three distinct groupings (overall simultaneous patterns vs. sequential patterns, simultaneous vs. sequential patterns during the first phase (first 12 months) and second phase of the study (12-24 months), simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study). As predicted, a greater percentage of individuals overall were in the simultaneous patterns of behavior change when the behavior pairs were homogeneous (51.2 percent). Comparatively, a greater percentage of individuals were in the sequential patterns of behavior change when the behavior pairs were heterogeneous (62.6 percent).

Among behavior pairs (homogeneous vs. heterogeneous), there was no significant difference between patterns of behavior change during the first and second phases of the study. Independent of type of behavior pair, in both the positively linked (homogeneous) and negatively linked (heterogeneous) behavior



pairs, more participants changed after the first phase of the study, and changed in a sequential manner.

The above findings provide support for the nature of the behavior pairs being linked with the way in which behaviors change. Homogeneous behavior pairs are associated with more simultaneous patterns of behavior change overall, which may be due to the fact that they are positively linked (both behaviors in a pair changing at a greater rate than predicted because they are similar in nature). This may ease change (since the behaviors are similar in nature) and thus facilitate the change of both behaviors at the same time. When looking at their pattern of change longitudinally, most behavior change is already occurring once the first phase of the study ends.

*Stage of Change.* It was hypothesized that participants who were in Preparation at baseline for both behaviors in a pair would be more likely to follow the simultaneous patterns of multiple behavior change than participants in the earlier Stages of Change at Baseline (PC/C or a combination of PC/C and Preparation). It was hypothesized that these would form within the three distinct groupings (overall simultaneous patterns vs. sequential patterns, simultaneous vs. sequential patterns during the first phase of the study (first 12 months), and the second phase of the study (12-24 months), simultaneous vs. sequential patterns for those who recycled behaviors during the course of the study). Surprisingly, the results within the three distinct groupings demonstrated no significant differences between patterns of behavior change and baseline Stage of Change. Thus, these results demonstrate no link between baseline Stage of Change and the order in

which behaviors change (simultaneously vs. sequentially). Consistent with the above results and analyses, and independent of Stage of Change, in both those in earlier and later stages at baseline, more participants changed in the second phase of the study (12-24 months) and changed in a sequential manner.

This study provides a new window into the process of behavior change, illuminating a new way in which to understand the underlying mechanisms of behavior change. The discovery that the majority of behavior change is sequential, rather than simultaneous, advances the field of multiple health behavior change in a novel way; even when behaviors are treated simultaneously they are more likely to change sequentially. Simultaneous treatment is producing more sequential behavior change, suggesting that simultaneous treatment of multiple health risk behaviors helps people to change even after treatment is over. This study provides a fresh look at behavior change and for the first time, sheds light on how different patterns of behaviors change over time. Regarding treatment implications for clinicians, this shows that clients may be making progress during treatment, which may not show up as behavior change until after treatment is over.

Limitations of this study include the use of only one kind of treatment (TTM-tailored intervention), the difference in sample size between those with heterogeneous and homogeneous behavior pairs, and between treatment and control groups, and the limited amount of time points to assess simultaneous vs. sequential behavior change patterns. Future research can examine severity and effort as predictors of sequential vs. simultaneous behavior change patterns. In

addition, future research may examine simultaneous vs. sequential patterns of behavior change among adolescents.

Table 1. *Overall Simultaneous vs. Sequential Paths (24 months)*

	Participants (n = 245)
	n (%)
Simultaneous- path 1	43 (17.6)
Simultaneous- path 2	16 (6.5)
Sequential- path 3	35 (14.3)
Sequential- path 4	39 (15.9)
Simultaneous- path 5	12 (4.9)
Sequential- path 6	5 (2)
Sequential- path 7	33 (13.5)
Simultaneous- path 8	16 (6.5)
Sequential- path 9	30 (12.2)
Simultaneous- path 10	16 (6.5)

Table 2. *Overall Simultaneous vs. Sequential Patterns (24 months)*

	Participants (n = 245)
	n (%)
Simultaneous	103 (42)
Sequential	142 (58)

Table 3. *Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and During the Second Phase of the Study (12-24 months)*

	Participants (n = 245)
	n (%)
Simultaneous Phase 1	59 (24.1)
Sequential Phase 1	39 (15.9)
Simultaneous Phase 2	28 (11.4)
Sequential Phase 2	119 (48.6)

Table 4. *Simultaneous vs. Sequential Patterns for those who Recycled Behaviors During the Course of the Study (24 months)*

	No Recycling (n = 177)	Recycled (n = 68)
	n (%)	n (%)
Simultaneous	75 (42.4)	28 (41.2)
Sequential	102 (57.6)	40 (58.8)

Table 5. Overall Simultaneous vs. Sequential Patterns (24 months) in Treatment Compared to Control Group Participants

	Control (n = 85)	Treatment (n = 160)	Chi-Square
	n (%)	n (%)	
Simultaneous	46 (54.1)	57 (35.6)	7.79**
Sequential	39 (45.9)	103 (64.4)	

\*\*p < .01



Table 6. *Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and During the Second Phase of the Study (12-24 months) in Treatment Compared to Control Group Participants*

	Control (n = 85)	Treatment (n = 160)	Chi-Square
	n (%)	n (%)	
Simultaneous Phase 1	25 (29.4)	34 (21.3)	16.22**
Sequential Phase 1	4 (4.7)	35 (21.9)	
Simultaneous Phase 2	15 (17.6)	13 (8.1)	
Sequential Phase 2	41 (48.2)	78 (48.8)	

\*\*p < .01

Table 7. *Simultaneous vs. Sequential Patterns for those who Recycled Behaviors During the Course of the Study (24 months) in Treatment Compared to Control Group Participants*

	Control (n = 37)	Treatment (n = 31)
	n (%)	n (%)
Simultaneous	15 (40.5)	13 (41.9)
Sequential	22 (59.5)	18 (58.1)

Table 8. Overall Simultaneous vs. Sequential Paths (24 months) Across Homogeneous and Heterogeneous Behavior Pairs

	Homogeneous Behavior Pairs (n = 82)	Heterogeneous Behavior Pairs (n = 163)	Chi-Square
	n (%)	n (%)	
Simultaneous	42 (51.2)	61 (37.4)	4.26*
Sequential	40 (48.8)	102 (62.6)	

\*p < .05

Table 9. *Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and During the Second Phase of the Study (12-24 months) Across Homogeneous and Heterogeneous Behavior Pairs*

	Homogeneous Behavior Pairs (n = 82)	Heterogeneous Behavior Pairs (n = 163)
	n (%)	n (%)
Simultaneous Phase 1	24 (29.3)	35 (21.5)
Sequential Phase 1	13 (15.9)	26 (16.0)
Simultaneous Phase 2	7 (8.5)	21 (12.9)
Sequential Phase 2	38 (46.3)	81 (49.7)

Table 10. *Simultaneous vs. Sequential Patterns for those who Recycled Behaviors During the Course of the Study (24 months) Across Homogeneous and Heterogeneous Behavior Pairs*

	Homogeneous Behavior Pairs (n = 10)	Heterogeneous Behavior Pairs (n = 58)	Chi-Square
	n (%)	n (%)	
Simultaneous	7 (70.0)	21 (36.2)	4.02*
Sequential	3 (30.0)	37 (63.8)	

\*p < .05

Table 11. *Overall Simultaneous vs. Sequential Patterns (24 months) Across Baseline Stage of Change*

	Combination of PC/C/PR (n = 145)	PR for both behaviors (n = 100)
	n (%)	n (%)
Simultaneous	61 (42.1)	42 (42.0)
Sequential	84 (57.9)	58 (58.0)

Table 12. *Simultaneous vs. Sequential Patterns During the First Phase of the Study (first 12 months) and During the Second Phase of the Study (12-24 months) Baseline Stage of Change*

	Combination of PC/C/PR (n = 145)	PR for both behaviors (n = 100)
	n (%)	n (%)
Simultaneous Phase 1	35 (24.1)	24 (24.0)
Sequential Phase 1	21 (14.5)	18 (18.0)
Simultaneous Phase 2	19 (13.1)	9 (9.0)
Sequential Phase 2	70 (48.3)	49 (49.0)

Table 13. *Simultaneous vs. Sequential Patterns for those who Recycled Behaviors During the Course of the Study (24 months) Across Baseline Stage of Change*

	Combination of PC/C/PR (n = 47)	PR for both behaviors (n = 21)
	n (%)	n (%)
Simultaneous	19 (40.4)	9 (42.9)
Sequential	28 (59.6)	12 (57.1)



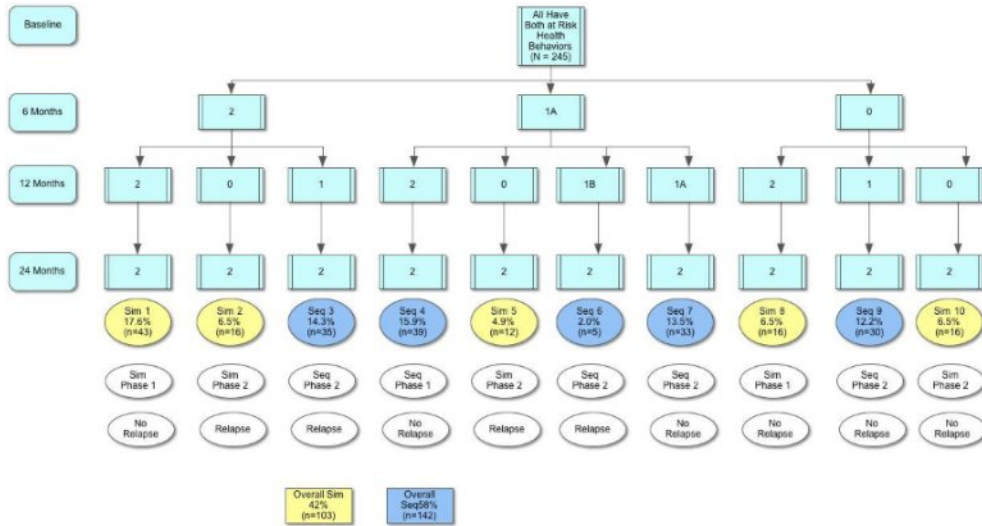


Figure 1. Simultaneous vs. Sequential Behavior Change Patterns

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