

2011

Validation Study of a Behavioral Based Instrument for Dietary Fat Consumption

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**VALIDATION STUDY OF A BEHAVIORAL BASED INSTRUMENT
FOR DIETARY FAT CONSUMPTION**

BY

HISANORI KOBAYASHI

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

IN

PSYCHOLOGY

UNIVERSITY OF RHODE ISLAND

2011

18573405

ABSTRACT

This study aimed to validate the dietary behavior questionnaire (DBQ) developed by a group of researchers from several different fields including nutrition, nursing and psychology (Rossi et al, 2008) adapted from the work of Kristal and colleagues (Kristal et al, 1990). The new instrument was designed to measure the behavior of dietary fat intake and involved 22 items with 4 theoretical constructs: Substitute, Moderate fat intake, Modify cooking, and Increase healthful foods. This study utilized multiple psychometric techniques including PCA, CFA, factorial invariance comparison (multi-group CFA), MANOVA and ANOVA using data from Rhode Island parents of high school students. The new data correctly replicated the original 4 factor models. The results from factorial invariance comparison using Cheung and Renswold's method suggested that the factor structure, loading pattern as well as covariance structure are invariant between pre-action stage group and post-action stage group and between females and males. All 4 theoretical constructs had adequate Cronbach's alphas (range: 0.62 – 0.77). MANOVA results suggested that the DBQ was correctly discriminated by TTM stages of change. Psychometric findings suggested that the new measurement had good reliability and validity, and is ready for the use in future fat intake research, especially in Transtheoretical model based behavioral research.

ACKNOWLEDGMENTS

I would like to thank my major professor Dr. Joseph Rossi for his exceptional support and incredible guidance throughout my years at the Psychology department. I would also like to thank Dr. Greene and Dr. Redding for serving on my graduate committee. Many thanks to Dr. Susan Rossi for being a chair of the committee. Finally, I would like to thank Dr. Redding for her generous permission to access her Parents Study data.

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CHAPTER 1

INTRODUCTION

An interest in healthy life style has been increasing among most of Americans. However, according to the latest statistics reported by the National Center of Health Statistics (NCHS), obesity rates have increased over the past 25 years (Ogden, Carroll, McDowell, & Flegal, 2007). In 2005-2006, 72 million U.S. adults were categorized as obese. This number includes more than one third of all U.S. adults 33.2% of men and 33.5% of women are obese. Although there have been no significant increases since 2002, but the rates were still almost double rates in the 1980's. Two main causes for obesity are excess energy intake and inadequate energy expenditure. Fat consumption is an important factor in daily calorie management. Dietary fat consumption is associated with the leading causes of death among Americans. On the other hand, consumption of Increase healthful foods has the potential to prevent certain diseases. Unfortunately, most Americans consume excess dietary fat and consume too few Increase healthful foods (Rossi et al., 2008, Vallis et al., 2003). Encouraging people to reduce dietary fat and increase healthful foods consumption will reduce the risk of many serious diseases. To assess and monitor dietary interventions, a standard behavioral assessment tool is needed. The assessment tool must be reliable, comprehensive, and functional. The result of this study is expected to yield a psychometrically sound and validated dietary instrument. The purpose of this study is

to validate one of the assessment tools, the dietary behavior measure (Rossi et al, 2008) from a psychometric perspective.

Dietary Behavior Questionnaire (DBQ)

The dietary behavior questionnaire (DBQ) was developed by a group of researchers from several different fields including nutrition, nursing and psychology (Rossi et al, 2008) based on the work of Kristal and colleagues (Kristal et al, 1990). The most meaningful difference of these measures compared with most other dietary measurements was that they focused on behaviorally based fat consumption rather than frequency or amount of fat consumed. Food frequency questionnaires have been widely used in dietary research. These measures assess how often several foods and nutrients are consumed (Block, 1982; Medlin, 1988). These measures have had high functionality (Willett, 1994), but numerous of researchers have criticized their validity and accuracy (Birkett & Boulet, 1995; Briefel et al, 1992). Kristal and colleagues developed a first generation behaviorally based fat consumption measure utilizing an anthropological theory (Jerome, 1976). They also found that measurement utilizing behavior was more sensitive to dietary change than a food frequency questionnaire (Kristal et al, 1994). However, several studies have failed to replicate the factor structure of their instrument (Birkett & Boulet, 1995; Greene et al, 1994). Rossi and colleagues developed a new version of a behavioral based fat consumption measurement (Rossi et al, 2008).

In the creation of this new measure, the researchers developed several criteria: the measurement should be short, inexpensive to conduct, appropriate for use in survey

and intervention research, low in subject response burden, suitable for telephone interview or self-administered mail format, and acceptable for regular re-administrations and behaviorally based to allow for individual feedback on specific behaviors. They employed a sequential method for scale construction that utilized both qualitative and quantitative analyses to make their measurement more psychometrically powerful (Redding et al, 2006). Literature review, conducting of focus groups, item generation, and expert review were included in the initial qualitative analyses. In quantitative analyses, they utilized item analysis, principal components analysis (PCA), measurement modeling, and validation on subsequent samples. Many of the initial items were adapted from existing versions of the Food Habits Questionnaire (FHQ) (Kristal et al, 1990). At the base point, they included 61 potential items from the FHQ and utilized a 5-point Likert scale (1 = never to 5 = almost always). In this process, the study collected 434 respondents by mailing surveys to randomly assigned Rhode Island residents. PCA was performed to ascertain the measures structure and shorten the questionnaire. Based on the PCA results, they reduced the instrument to 22 items from the initial 61 questions. Table 1 presents the 22 DBQ items. They also identified 4 factors related to dietary fat intake: Substitute, Moderate fat intake, Modify cooking, and Increase healthful foods. The first factor, Substitute, refers to substituting high fat foods with lower fat alternatives. The second factor, Moderate fat intake, refers to eating high fat foods less often and in smaller portions. The third factor, Modify cooking, refers to reducing dietary fat in cooking and food preparation. The fourth factor, Increase healthful foods, refers to eating more fruits, vegetables, and whole grains. The previous study showed the correlation

between these factors and consuming calories a day: Substitute = .352, Moderate fat intake = .391, Modify cooking = .255, and Increase healthful foods = .182. In addition, the study collected an additional 475 respondents by random digit dial telephone survey from among Rhode Island residents to validate the initial findings of the factor structure. The second study found that the four factors (and one higher order factor) with 22 items were adequate. Figure 1 shows their final model (hierarchical). They concluded that a five dimension hierarchical model provided the best fit to the data. Finally, they postulated a final version of the DBQ as a promising rapid dietary fat assessment tool for use in survey research (Rossi et al., 2008).

The Transtheoretical Model (TTM)

This new version of behavioral based fat consumption measurement involved the Transtheoretical Model (TTM) (DiClemente & Prochaska, 1982; Prochaska, DiClemente & Norcross, 1992). The TTM is a useful framework for understanding behavioral change. The model postulates constructs including ten processes of change (Prochaska, Velicer, DiClemente, & Fava, 1988), five different stages of change (DiClemente, et al., 1991), decisional balance (Prochaska, et al., 1994) and self-efficacy and temptation (Velicer, DiClemente, Rossi, & Prochaska, 1990). The TTM was originally applied to smoking behavior, and the application expanded across other health behaviors such as alcohol use, sunscreen use, condom use, exercise and dietary fat intake (Greene et al., 1994; Vallis et al., 2003; Prochaska et al., 1994). In the conceptual dimensions of the TTM, “the stages of change” construct is the core. “The stages of change” refers to the temporal nature of a behavioral change. The construct

contains five distinct stages: precontemplation (PC), contemplation (C), preparation (P), action (A) and maintenance (M) (Prochaska, DiClemente, & Norcross, 1992). A person in the precontemplation stage would have no intention of changing his current behavior. A person in the contemplation stage would be thinking about changing his current behavior within the next six months. In the preparation stage, a person would think about changing his current behavior within the next 30 days. A person in the action stage is engaging in the target behavior but has been doing so for less than 6 months. Finally, a person in the maintenance stage has been actively engaged in the target behavior for over six months. The target behavior in this study is reducing the amount of dietary fat. The processes of change contain ten overt and covert strategies that individuals utilize in order to modify, adopt, or eliminate a target behavior. The 10 processes of change can be divided into two categories: experiential and behavioral. The experiential category is defined as processes that promote change through the use of emotional and/or cognitive strategies. The behavioral category is defined as processes that promote change through the use of specific strategies and actions. Decisional balance refers to an individual's balance of pros (advantages) and cons (disadvantages) for adopting a specific behavior. Self-efficacy refers to an individual's confidence in their ability to perform the desired behavior. Temptation refers to how tempted an individual is to not engage in the desired behavior in a variety of situations. The basic application strategy of the TTM to a target behavior involves assessing the stage of change, then based on that assessment information, building and promoting the use of individual tailored processes of change aimed at moving one through the stages. Both cross-sectional and longitudinal studies have shown evidence

to support the rationale of the TTM (DiClemente et al., 1991). The DBQ was built as a reliable measure, especially useful for TTM based interventions of fat reduction and is also applicable for other non-TTM based studies as well.

Interventions

Currently, a number of clinic-based options for the treatment of obesity are available. TTM tailored interventions have been adapted for this particular behavior as well as intervening on multiple behaviors, such as healthy eating, exercise and managing emotional distress simultaneously (Johnson et al., 2008). Intervening on multiple healthy behaviors simultaneously is one of the most effective ways to promote healthy life style (U.S. Department of Health and Human Services, 2000). The multi-intervention strategy is an effective way to reduce health care costs (Edington, 2001). A number of studies support an advantage in using TTM tailored interventions (Prochaska et al., 2004, 2005). Jones et al. (2003), for example, compared usual care with TTM tailored treatment in participants with diabetes and showed a significant advantage in using TTM tailored treatment. They recruited 1,029 individuals with type1 and type2 diabetes. All individuals were in one of three pre-action (i.e. precontemplation, contemplation and preparation) stages for one of three behaviors; self-monitoring of blood glucose (SMBG), healthy eating and smoking. They demonstrated that more participants who received TTM tailored intervention moved to the action stage than those who received standard treatment for the SMBG intervention with strips (43.4% vs. 27.0%), for the SMBG intervention without strips (30.5% vs. 18.4%), for the healthy eating intervention (32.5% vs. 25.8%), and for the smoking intervention (24.3% vs. 13.4%). Finally, treatment group behavior changes

were also evident in Hemoglobin A1C measurements, an index of diabetes severity (Jones et al., 2003)

Hypotheses

This study was designed to investigate the validity of the dietary behavior questionnaire (DBQ) (Rossi et al, 2008). The most macro level hypothesis was that the DBQ should be a reliable and consistent measure across different target populations, with the new data set replicating the same factor structure as the original study showed (Rossi et al, 2008). Figure 1 shows the model found by Rossi et al. To investigate this broad hypothesis, the following micro level hypotheses were examined.

1. The new data should represent 4 correlated latent factors: Substitute, Moderate fat intake, Modify cooking, Increase healthful foods. This hypothesis demonstrates that the DBQ is reliably measuring four constructs.
 - 1a. The new data should represent that the first factor (i.e. Substitute) is measured by question items 1 to 5 (see Table 1 and Figure 1). This hypothesis demonstrates that question items 1 to 5 are reliably measuring substituting high fat foods with lower fat alternatives.
 - 1b. The new data should represent that the second factor (i.e. Moderate fat intake) is measured by question items 6 to 10 (see Table 1 and Figure 1). This hypothesis demonstrates that question items 6 to 10 are reliably measuring eating high fat foods less often and in smaller portions.
 - 1c. The new data should represent that the third factor (i.e. Modify cooking) is measured by question items 11 to 15 (see Table 1 and Figure 1). This

hypothesis demonstrates that question items 11 to 15 are reliably measuring reducing dietary fat in food preparation.

- 1d. The new data should represent that the fourth factor (i.e. Increase healthful foods) is measured by question items 16 to 22 (see Table 1 and Figure 1). This hypothesis demonstrates that question items 16 to 22 are reliably measuring eating more fruits, vegetables, and grains.
2. The final correlated 4 factor model should provide an adequate fit to the data; $CFI > .90$ and $RMSEA < .08$. This hypothesis demonstrates that the DBQ model should fit well with the new data.
3. The final correlated 4 factor model also should have a potential to have one higher order factor.
4. The TTM stages should represent a similar factor structure (configural invariance) and similar fit parameter matrices (i.e. metric invariance). The hypothesis explains that the DBQ's stability of across different stages.
5. Male data and female data should represent similar factor structure (configural invariance) and similar fit parameter matrices (i.e. metric invariance). The hypothesis explains the DBQ's stability across gender.
6. The new data should show significant mean differences across the TTM's stages of change, and should have adequately high effect sizes. The hypothesis explains that the DBQ should have "known groups validity" (Redding et al., 2006).

CHAPTER 2

METHODS

Participants

This study is a secondary data analysis of a data set which was collected in the “Parent Study 2002” (Redding et al., 2002). The Parent Study was approved by the Institutional Review Board for Human Subjects and recruited 2547 target parents who provided informed consent. After the participants agreed to participate the study, they were randomized into one of three intervention groups: 1). Benchmark expert system (ES) (diet, sun, smoking); 2). New Behaviors ES (exercise, stress, alcohol); and 3). Enhanced ES (diet, sun, smoking), using URN randomization based on gender (male; female). Since the aim of the “Parents Study 2002” targeted sets of multiple behaviors, the participants in different groups were given different behavioral surveys. This study only investigated participants surveyed about dietary behavior (i.e. participants who completed the diet behavior questionnaire). In the Parent Study, the participating parents’ spouse or significant other were also recruited into the study. Their group was not randomized, but linked to the group of target parent. There was a strong correlation between the parents and their partners. Thus, we conducted the analyses after excluding partners from the data. After excluding the partners and participants with drop-out and missing data, 1366 participants remained. Table 2 describes the participant characteristics. There were 850 (62.2%) female and 516 (37.8%) male participants. In the sample, 919 (76.1%) parents were married, 55 (4.6%) were not

married and living with a partner, 24 (2%) were not married or not living with a partner, 23 (1.9%) were separated, 159 (13.3%) were divorced, and 25 (2.1%) were widowed. One-hundred-sixty-six parents did not respond about their marital status. Average age was 43.94 years old and the standard deviation of 6.01. Ten participants did not respond with their age. According to self report, 175 (14.6%) participants were in excellent health, 508 (42.3%) participants were in very good health, 403 (33.6%) participants were in good health. 97 (8.1%) participants were in fair health, and 17 (1.4%) participants were in poor health. One-hundred-sixty-six participants did not respond about their health status. Finally, based on the Transtheoretical Model (TTM) stages of change scale for dietary fat reduction (Prochaska, DiClemente, & Norcross, 1992), 575 (42.7%) participants were in the precontemplation stage, 115 (8.6%) participants were in the contemplation stage, 269 (20%) participants were in the preparation stage, 38 (2.8%) participants were in action stage, and 349 (25.9%) participants were in the maintenance stage. Stage could not be calculated for 20 participants because of missing responses. Table 2 presents the overall summary of participants' characteristics.

Instruments

All surveys were approved by the Institutional Review Board (IRB) and followed APA ethical standards for research. This study focused on demographic questionnaires, the dietary behavior questionnaire (DBQ), and the Transtheoretical model (TTM) (Prochaska, DiClemente & Norcross, 1992) scales, the stage of change scales, and related items. Demographic variables were not analyzed directly in the main analysis, but were necessary to show the limitations for internal and external

validity of this study. Moreover, the gender variable was utilized by additional analyses in the CFA invariance comparison.

The dietary behavior questionnaire (DBQ) contains 23 items about participants' eating style over the past month. Table 1 shows the list of 23 items. This assesses participants' current behavior related to controlling fat consumption and increasing fruits, vegetables and whole grains consumption. The items include 17 positive items, for lower fat food consuming habits and high frequent fruit consuming habits, and 6 negative items, for higher fat food consuming habits and low healthful food consuming habits, and appear alternately. The number of positive and negative items per scale is not equal, but contains enough items to control response biases related to acquiescence. All the DBQ items utilize a five-point Likert scale (5=Almost always, 4=Often, 3=Sometimes, 2=Rarely, 1=Never) which has been preferred by several researchers (e.g., Redding et al., 2006). This study excluded one item "How often did you reduce the amount of butter, margarine, or oil in a recipe to cut down on fat?", and focused on 22 items in the measure. Reasons for this exclusion were 1) The original measure developed by Rossi and colleagues (Prochaska et al., 2004; Rossi et al., 2008) did not contain this item, 2) Any theoretical support for adding this item could not be found, 3) There was no theoretical information about which factor (sub construct) would contain this item. Thus, this study utilized the 22 item version of measure. Also, this measure has 4 theoretical constructs, and all 22 items are within the one of four constructs. The four constructs measuring dietary fat intake include: Substitute, Moderate fat intake, Modify cooking, and Increase healthful foods. The first factor, Substitute, refers to substituting high fat foods with lower fat alternatives. The second

factor, Moderate fat intake, refers to eating high fat foods less often and in smaller portions. The third factor, Modify cooking, refers to reducing dietary fat in food preparation. The fourth factor, Increase healthful foods, refers to eating more fruits, vegetables, and grains.

Several studies have supported the validity of other TTM based instruments using multivariate analysis of variance (MANOVA) between these instruments and the TTM's stages of change (e.g. Rossi et al., 2001). Most of time, these instruments have shown statistically significant differences among the stages, and the results support the measures' "known group validity". For reliability, the Coefficient Alphas should be at least 0.6, and Rossi et al. (2001) mentioned a related set of measurements had reasonably high coefficient Alpha. These psychometric results have supported that it is reasonable to measure these set of constructs and supported that some part of background assumptions for conducting SEM (Jöreskog, 1967, 1969) procedures.

Analyses

To assess the validity of the dietary behavior questionnaire (DBQ)'s psychometric properties, this study conducted several psychometric procedures including multivariate analysis of variance (MANOVA), principal components analysis (PCA), confirmatory factor analysis (CFA), and invariance nested model comparisons. Some of these psychometric procedures are included in the structural equation modeling (SEM) framework. In this study, AMOS6 was used for SEM procedures. Other psychometric procedures were conducted, such as calculating descriptive statistics, PCA, and MANOVA using SPSS14 and SAS 9.2.

As an initial step of the analysis, the overall sample was divided into two subgroups to conduct a “cross-validation” approach. These two subgroups were randomly selected from the overall sample. This procedure was done using SPSS 14. In this procedure, descriptive statistics of demographic data were checked for each half of the data and are presented in Table 3. The cross-validation approach was adapted to only PCA and reliability analysis (i.e. Cronbach’s alpha). In general, PCA is conducted on the first subgroup as an exploratory group and CFA is conducted on the second subgroup as a validation group in a measure development study. However, since the goal of this study was validating an instrument and did not intend modifying the scale, the PCA and the reliability analysis were conducted on the first and the second subgroups to see the replication of each result. On the other hand, CFA and MANOVA were conducted to see the validity of original measure. The results of CFA was compared with original study, and MANOVA tested theoretical “known groups” validity, thus these procedures were conducted on the full sample.

Second, PCA was performed to validate the model structure among the manifest and latent variables in the DBQ. This analysis was performed on both the first and the second sample to see the measurement reliability among different samples. To determine the number of factors, this study looked at both Kaiser’s rule (i.e. retaining the factors having eigenvalues greater than 1.00) and parallel analysis (PA) (Lautenschlager, 1989). Also, to interpret factor structures, Varimax with Kaiser normalization was used as the rotation method. This analysis investigates how many factors exist and how variables and factors relate. The factor structure among manifest

and latent variables was compared with the original model structure proposed in the initial study (Rossi et al, 2008).

After validating the factor structures, CFA was performed to test the actual model fit. The CFA was conducted on a full sample (N=1366) using AMOS6 and maximum likelihood estimation. The result of the CFA procedure was used not only to see model fit, but for Modify cooking of model structures to improve model fit. This study evaluated multiple fit indices: χ^2 value, the comparative fit index (CFI) and the root-mean-square of approximation (RMSEA). However, since overall χ^2 value is highly influenced by sample size (Byrne, 2001; Kline, 1998), not much weight was attributed to the actual values of χ^2 . The CFI evaluated the fit between the null model and the proposed model CFI values greater than .90 indicate a reasonably good fit (Hu & Bentler, 1999). Also, a value of RMSEA less than .05 indicates a good fit, RMSEA between .05 through .08 indicates fair fit, and RMSEA between .08 through .10 indicates a mediocre fit (Browne & Cudeck, 1993). After these procedures, the initial model from the original study presented in Figure 1 (Rossi et al., 2008) was compared with the new proposed model from this analysis.

Next, this study investigated the measure's stability among several different groups, based on gender and the stage of change (DiClemente et al., 1991). A factorial invariance comparison (Byrne, Shavelson, & Muthen, 1989) also known as Multi Group Confirmatory Factor Analysis (MG-CFA) was performed on these groups. This procedure tested four models; the congeneric model (configural invariance), the lambda-invariant model (metric invariance), the tau-equivalent model, and the parallel model. The congeneric model (configural invariance) is the least restrictive model

assuming the two samples have the same factor structure, but different loadings, factor variances, and error variances. The lambda-invariant model (metric invariance) is the same as the congeneric model, but also assumes factor loadings to be equal across both samples. The tau-equivalent model is the same as lambda-invariant model, except it also assumes the same factor variances and co-variances across the two samples. The parallel model is the most restrictive model, assuming every parameter estimate to be equal across both samples. These models represent a sequence of progressively more restricted tests of structural invariance across the two samples. This study utilized the bottom-up procedure by starting with the least restricted model and progressively moving to more restrictive models using χ^2 difference test. Significant χ^2 indicates that the more restricted model is a significantly worse fit than the less restricted model should be retained, and should retain the less restricted model. This study also utilized goodness of fit indexes: CFI, unbiased GFI (gamma-hat) (Steiger, 1989), and McDonald's (1989) Non-Centrality Index (NCI), to test measurement invariance (Cheung & Rensvold, 2002). In Cheung and Rensvold's method, differences of fit indexes between less restricted and more restricted model are evaluated. That is the difference of CFI (Δ CFI) is obtained by subtracting the CFI of congeneric model from the CFI of lambda invariant model. A Δ CFI value less than -0.01, Δ Gamma-hat less than -0.001 and Δ NCI less than -0.02 indicates that the more restricted model is a significantly worse fit than the less restricted model, and thus the less restricted model should be retained.

As a last step, a MANOVA was performed on a full sample to examine the mean difference of the DBQ scale scores between the TTM stages of change. This procedure

tests evaluated the DBQ's discriminant (known groups) validity. This procedure also included several tests for ANOVA assumptions. Descriptive statistics were utilized to see the normality assumption. Levene's test and residual analyses were utilized to test the homogeneity of variance. The residual analyses were conducted by SAS 9.2 using command "plot=(diagnostic)" command under GLM procedure. This command outputs 8 different plots, which are widely used in diagnostic tests, and a set of informative statistics. Some of plots are not applicable to use in procedure using ANOVA, but usable in regression based procedure. This study mainly focused 2 plots: residual by predicted value, residual by quantile. In the first plot, all residuals being between ± 3 standard deviation are desirable. In the second plot, linearly plotted residuals are desirable. The MANOVA procedure included 4 independent ANOVA procedures to test which dependent variables contained significant mean differences across levels of the independent variable (the stages of change). The ANOVA procedures also included Tukey's multiple comparison procedure to test which levels of independent variable (the stages of change) contained significant mean differences. Effect sizes were also computed for each model. In the MANOVA procedure, multivariate η^2 was computed and was interpreted as a multivariate effect size. In ANOVA procedures, η^2 was computed and was interpreted as a univariate effect size.

CHAPTER 3

RESULTS

Split Half

The original 1366 participants were split into one of two groups randomly based on SPSS split half function. The first group was set as an “Exploratory Group” and mainly analyzed in the study. The second group was set as a “Validating Group” and analyzed only for validating purposes. Table 3 presents the descriptive statistics for both samples. As expected, all the demographic information between the 2 groups was similar. The reliability analysis was conducted for both samples.

Principal Components Analysis (PCA)

The purpose of this analysis was to investigate the model structure among the manifest and the latent variables in the dietary fat intake measure (DBQ). The first PCA was performed without setting the number of components. Using Kaiser’s rule, the result showed that 5 components had eigenvalues greater than 1, and those 5 components explained 52.09% of variance. Using parallel analysis (PA) approach (Lautenschlager, 1989), the results showed that 5 components had eigenvalues greater than the PA’s criteria. Table 4 presents the rotated component matrix using Varimax with Kaiser Normalization method. Since the original DBQ was proposed with 4 components, a second PCA was performed forcing 4 components. As expected, the explanatory power of components was decreased to 46.61%. Table 5 presents the rotated component matrix using Varimax with Kaiser Normalization method. The

component structure was almost identical to the original model proposed by Rossi et al. (2008). The third PCA was the replication of the first PCA but used the second subsample (i.e. Validation Group). Hypothetically, this analysis should suggest the same number of components as the first PCA. Using Kaiser's rule, the result showed that 6 components had eigenvalues greater than 1, and those 6 components explained 56.14% of variance. Using parallel analysis (PA) approach, the results showed that 5 components had eigenvalues greater than the PA's criteria, and those 5 components explained 51.48% of variance. Table 6 presents the rotated component matrix using Varimax with Kaiser Normalization method. For the same reason, a fourth PCA was performed forcing 4 components. As expected, the explanatory power of components was decreased to 46.08%. Table 7 presents the rotated component matrix using Varimax with Kaiser Normalization method. This component structure was identical as the component structure of second PCA on the exploratory sample.

Confirmatory Factor Analysis (CFA)

The purpose of this analysis was to investigate actual model fit using a full sample (N=1366). First CFA was performed based on the 4 constructs that resulted from the PCA result (see table 6 & 8). The model fit summary showed the χ^2 value was significant, $\chi^2(203) = 1239.85$, $p < 0.001$. This indicated that the model did not adequately fit the data. However, as mentioned earlier, the χ^2 test is highly influenced by the sample size, and there is a high probability of getting statistical significance with large sample sizes (Byrne, 2001; Kline, 1998). The model fit summary also showed the Comparative fit index (CFI) = 0.85 and RMSEA = 0.061. This CFI was

not impressive as approaching 0.9 is considered as good fit. This RMSEA indicated the model fit was fair.

A second CFA was performed based on the original factor structure proposed by Rossi et al (2008) except that the second model used correlated factors instead of a higher order factor. Figure 1 presents the original CFA model. The result showed that the χ^2 value was significant, $\chi^2(203) = 1514.27$, $p < 0.001$, CFI = 0.81, and RMSEA = 0.069. As expected, the model fit was worse than the first model. However, since the main focus of this study is validating the original measure, using the second model was theoretically more rational than using the first model that resulted from the PCA. Therefore, decision was made to utilize the second model as a base model to improve the model fit.

A third CFA was performed based on the second model and its modification indices. Figure 2 presents this CFA model. After three correlation paths between the residuals were added into the model, the fit indices approached a desirable level, $\chi^2(200) = 885.75$, $p < 0.001$, CFI = 0.90, and RMSEA = 0.050.

Factorial Invariance Comparison (Multi Sample CFA)

The purpose of this analysis was to investigate model stability among different populations (i.e. pre-action vs. post-action, female vs. male). This procedure tested 4 models (i.e. Congeneric, Lambda-invariant, Tau-equivalent, Parallel) for each of two sets of compared groups. First a group in the Precontemplation, Contemplation, or Preparation stages was examined against a group in the Action or Maintenance stages. Second, an examination groups by gender was done. Table 8 shows the results using

the χ^2 difference test. Table 9 shows the results using Cheung and Rensvold's method. In the first comparison, a statistically significant χ^2 value ($\Delta\chi^2(18) = 56.26, p < 0.05$) was found when comparing between Congeneric and Lambda-invariant models. This χ^2 difference test indicated that the Lambda-invariant model was significantly worse than the Congeneric model, thus indicating the Congeneric model should be retained. Cheung and Rensvold's method showed the Parallel model was worse than the Tau-equivalent model and indicated that the Tau-equivalent should be retained ($\Delta CFI = -0.049$, $\Delta\text{Gamma-hat} = -0.014$, $\Delta\text{NCI} = -0.063$). In the second comparison by gender group, a statistically significant χ^2 value ($\Delta\chi^2(25) = 60.37, p < 0.05$) was found when comparing between Tau-equivalent and Parallel models. This χ^2 difference test indicated that the Parallel model was significantly worse than the Tau-equivalent model, thus indicating the Tau-equivalent model should be retained. Cheung and Rensvold's method did not show any meaningful difference, and indicated that the Parallel model should be retained.

In addition, Table 10 presents the Cronbach's alphas for each of the 4 theoretical subcategories: Substitute, Moderate fat intake, Modify cooking and Fruit and Veggies, for both samples.

Multivariate Analysis of Variance (MANOVA)

The purpose of this analysis was to investigate the known groups validity of the behavioral dietary fat intake measure (DBQ) using a full sample (N=1366). Table 11 presents descriptive statistics of 4 means of dependent (response) variables: Substitute, Moderate fat intake, Modify cooking and Increase healthful foods. The minimum

values were 1 and the maximum values were 5, because all items used a Likert scale (Choice of 1 to 5) format. All standard deviations were less than the means, and the range was 0.69 to 1.02. All skewnesses were in the range of between -0.12 and 0.11, and it suggesting that the data was fairly normally distributed. Finally, all kurtosis were in the range of between -0.74 and 0.41, which suggested that the data had no high or low kurtosis. All correlations among the dependent variables were between 0.29 and 0.52, with highest correlation between Substitute and Moderate fat intake subcategories. This indicated that there was little chance of multi-collinearity, because all correlations were less than 0.7. Multivariate analysis of variance (MANOVA) on all 4 diet subscales showed a statistically significant difference using Wilk's Lambda, $F(16, 4088) = 51.48, p < .001$. The multivariate effect size, η^2 was .43, was a large effect size, according to Cohen's (1992) guidelines (i.e. small = .02, medium = .13, large = .26).

Four independent ANOVAs were performed for each of four subcategories one at a time. The first ANOVA tested food Modify cooking subcategory across the stages of change groups, and showed statistical significant mean difference, $F(4, 1341) = 24.35, p < .001$. The univariate effect size, η^2 , was .068, was a medium effect size, according to Cohen's guidelines (i.e. .01 = small, .06 = medium, .13 = large). However, Levene's test showed a significant result for Modify cooking, $F(4, 1341) = 6.56, p < .001$. This indicated that the data may violate the homogeneity of variance assumption. However, a plot of residual by predicted value (see Figure 4) showed the residual varying between +1 and -3 standard deviation. The variance of precontemplation stage seems wider than other stages. This result may happen because

the unequal sample size among the 5 stages. The residual by quantile plots (see Figure 4) showed fairly linear plotting. The descriptive statistics showed skewness and kurtosis, suggesting the data was fairly normal. Also, this analysis used a large sample size (over 1000), thus this test is assumed to be robust for a violation of assumptions. Therefore, it was decided not to transform the data. Tukey's pairwise multiple comparison test with using 0.05 alpha level, showed significant mean differences between precontemplation and maintenance, between contemplation and maintenance, and between preparation and maintenance.

The second ANOVA tested food Substitute subcategory across the stages of change groups, and showed a statistically significant mean difference, $F(4, 1341) = 143.80, p < .001$. The univariate effect size, η^2 , was .30, and was a large effect size, according to Cohen's guidelines. This time, Levene's test did not show significance. This indicated that the data assumed homogeneity of variances. Tukey's pairwise multiple comparison test showed significant mean differences across most of the groups except between precontemplation and contemplation, between contemplation and preparation, and between action and maintenance.

The third ANOVA tested Moderate fat intake subcategory across the stages of change groups, and showed statistically significant mean differences, $F(4, 1341) = 156.28, p < .0001$. The univariate effect size, η^2 , was .32, and was a large effect size, according to Cohen's guidelines. However, Levene's test was significant, $F(4, 1341) = 3.88, p = .04$). This indicated that the data may violate the homogeneity of variance assumption. For the same reason based on the descriptive statistics and the diagnostic tests (i.e. residuals varying between ± 2 and linearly plotted, see Figure 5) as the first

ANOVA test, thus decided to utilize original data in this analysis without any transformation. Figure 5 presents the residual plots. Tukey's pairwise multiple comparison test showed significant mean differences across most of the groups except between precontemplation and contemplation, between contemplation and preparation, and between action and maintenance.

The fourth ANOVA tested Increase healthful foods subcategory across the stages of change groups, and showed significant mean differences, $F(4, 1341) = 72.49$, $p < .001$. The univariate effect size, η^2 , was 0.18, a large effect size. Levene's test was a significant, $F(4, 1341) = 3.64$, $p = .006$, indicating that the data may violate the homogeneity of variance assumption. For the same reason based on the descriptive statistics and the diagnostic tests (i.e. residuals varying between ± 2 and linearly plotted, see Figure 6) as the first and the third ANOVA test, it was decided original data without any transformation would be used in this analysis. Figure 6 presents the residual plots. Tukey's pairwise multiple comparison test showed significant mean differences between precontemplation and action, between precontemplation and maintenance, between contemplation and action, between contemplation and maintenance, between preparation and action, and between preparation and maintenance.

In addition, Figure 3 presents the mean scores of 4 subcategories across the stages of change. This shows that the post-action stage has higher scores than in the pre-action stage in all subcategories. Also, Table 12 presents means, standard deviation, F values, η^2 and Tukey test results of the 4 subcategories based on the 5 stages of change.

CHAPTER 4

DISCUSSION

The multiple psychometric techniques using 1366 participants supported the 4 factor structure of DBQ and its validity and reliability.

The first and the second principal components analyses (PCA) were performed using the first half of sample. The only difference between the first and the second PCA was that the second PCA forced 4 components. The result of first PCA showed that the measure should contain 5 components. The fifth component involved item 17: How often did you eat dark bread? and item 22: How often do you eat bread, rolls, or muffins made from whole grains (whole wheat, rye, pumpernickel)? These two items were originally included in the Increase healthful foods component. However, the two items both concerned consuming bread, and thus, the PCA indentified the fifth component as a bread category. Also, item 8: If you eat red meat, how often did you eat small portions to cut down on fat? and item 10: How often did you avoid putting butter or margarine on your bread to cut down on fat? were included in the Substitute component. Originally, these two items were designed to be in the Moderate fat intake component. This indicated that these items have the potential to be complex items. The results of the second PCA showed that the measure had the same component pattern with the theoretical model proposed by the original work (Rossi et al. 2008) except for items 8 and 10. This indicates that the measure has reasonable construct validity. The third and the fourth PCA were performed using the second half of sample. The difference between the third and the fourth PCA was that the fourth PCA

forced 4 components. The result of the third PCA showed same component pattern as the first PCA except this time, the Increase healthful foods component was identified as 3 components: 2 Increase healthful foods components and a bread component). This indicates that the Increase healthful foods subscale is comparatively less stable than other three subscales. However, after forced the number of components to 4, the component structure was identical with the second PCA. This indicates the measurement's stability of component pattern.

Confirmatory factor analysis (CFA) suggested that the data fit adequately with the theoretical measurement model after several modifications. This indicated that the new data supported that the DBQ measure had a fairly concrete theoretical construct; Substitute, Moderate fat intake, Modify cooking and Increase healthful foods. The model modifications included setting 3 correlation paths between the residual of item 6 and 9, item 17 and 22 and item 19 and 20. This indicated that these sets of items were correlated by their own unique factors. For instance, item 17 and 22 both concerned bread consumption. Thus, these items could be correlated in outside of their theoretical factor, Increase healthful foods. The PCA also indicated the same finding about these measures. Since the original study included the same correlation paths among the residuals, these items had some potential to improve.

The χ^2 difference test in the first factorial invariance comparison suggested that the participants in the pre-action stage might use a same factor structure as other participants in post-action stage using, but they used different factor loadings patterns. This finding indicated that the coefficients of each item, correlations between common factors and the residuals of each item were different depending on the stages. At the

same time, however, results of Cheung and Rensvold's method suggested that the participants in pre-action stage had a similar factor pattern as other participants in post-action stage had, except for the residuals of each item. This finding indicated that the two different groups used an almost identical factor pattern. The χ^2 difference test in the second factorial invariance comparison suggested that female participants had a similar pattern as male participants had, except for the residuals of each item. This finding indicated that the two different groups used almost identical factor pattern. At the same time, however, the results of Cheung and Rensvold's method suggested that the two groups used the identical factor pattern.

The Cronbach's alpha showed range between 0.62 and 0.77. This indicates that the DBQ measure is a fairly reliable measure. The Substitute category had the highest alpha value in both sample cases (0.77 in sample1 and 0.76 in sample2). This indicates that the Substitute category is the most concrete and the most reliable measure in the DBQ measure. On the other hand, the Moderate fat intake category had lowest alpha value in both samples (0.62 in sample1 and 0.63 in sample2). This indicates that the Moderate fat intake category is less concrete and less reliable than other 3 categories. Between the two samples, all alpha values were similar and this indicates the measurement constancy.

The MANOVA suggested that there was a significant mean difference across the stages of change. The assumptions of ANOVA were tested using the descriptive statistics, the Levene's tests and the diagnostic tests, and these results showed that this data met the assumptions of ANOVA. This indicated that the linear combination of DBQ scores; Substitute, Moderate fat intake, Modify cooking, and Increase healthful

foods, was correctly discriminated by the participants' stage. The first ANOVA and Tukey's pair wise multiple comparison suggested that the mean score of Modify cooking was correctly discriminated by between precontemplation and maintenance, between contemplation and maintenance, and between preparation and maintenance. The second ANOVA and Tukey's pair wise multiple comparison suggested that the mean score of Substitute was correctly discriminated by most pairs of stage except between precontemplation and contemplation, between contemplation and preparation, and between action and maintenance. The third ANOVA and Tukey's pair wise multiple comparison suggested that the mean score of Moderate fat intake was correctly discriminated by most pairs of stage except between precontemplation and contemplation, between contemplation and preparation, and between action and maintenance. The fourth ANOVA and Tukey's pair wise multiple comparison suggested that the mean score of Increase healthful foods was correctly discriminated by between precontemplation and action, between precontemplation and maintenance, between contemplation and action, between contemplation and maintenance, between preparation and action, and between preparation and maintenance. Most multiple comparisons did not show significant mean differences between precontemplation and contemplation, between contemplation and preparation and between action and maintenance. Since the actual behavior of fat consumption should be changed after the action stage, these findings were expected.

CHAPTER 5

CONCLUSION

This study tried to validate the dietary behavior questionnaire (DBQ), a measure originally developed by Rossi et al (2008), from a psychometric perspective. The original purpose of this instrument was to be an outcome measure of TTM based intervention for dietary fat intake. A number of studies have supported the effectiveness of TTM tailored interventions for this behavior as well as for intervening on multiple risky behaviors (Johnson et al., 2008; Prochaska et al., 2004, 2005). Overall, multiple psychometric procedures showed acceptable validity and reliability of DBQ measure. The SEM based analyses, including the PCA, the CFA and the factorial invariance testing, indicated that the new measure has a fairly concrete factor structure. The DBQ measure incorporates 4 correlated subcategories: Substitute, Moderate fat intake, Modify cooking, Increase healthful foods, with all SEM based analyses supported their theoretical factor structure fairly well. The Cronbach's alpha based on the 4 subcategories indicated that the new measure has reasonably high reliability. The MANOVA indicated that the new instrument has high discriminative power by TTM stages of change algorithm. In conclusion, that these psychometric findings suggested that the new instrument is ready for use in future dietary fat intake research, especially in TTM based intervention research.

LIMITATION

Findings in this study were based on data which came from parents and thus, the generalizability of this study is limited. The original study was conducted on a sample from general population. The minor differences on factor structures and on other results might be due to the difference of sample characteristics. At the same time, however, validating this instrument on sample of parents was also greatly meaningful. Parents have a high responsibility on managing food consuming habit in daily life. Therefore, parents are one of the target populations for dietary intervention study. Moreover, for other populations, their food consuming habits should also be strongly related with their parents' food consuming habits. As mentioned in the previous chapter, this study found multiple items having some potential to improve. If these items were improved, the new measure should be even more powerful. Finally, future studies using more broadly representative and heterogeneous participants and improved items are strongly desirable.

APPENDICES

Tables

Table 1. Dietary Behavior Questionnaire (DBQ)

Factor 1- Substitute

01. How often did you substitute low fat dairy products for regular dairy products?
02. If you eat salads, how often did you use light, fat free, or no dressing?
03. If you ate cheese (including cheese on sandwiches or in cooking), how often did you substitute fat-reduced or low fat cheese?
04. How often did you substitute low fat foods for high fat foods?
05. If you used mayonnaise, how often did you use diet, low calorie mayonnaise instead of regular?

Factor 2-Moderate fat intake

06. How often did you eat French fries?
07. How often did you eat hamburgers, hot dogs, or luncheon meats?
08. If you eat red meat, how often did you eat small portions to cut down on fat?
09. How often did you eat tacos, hamburgers, and other fast foods?
10. How often did you avoid putting butter or margarine on your bread to cut down on fat?

Factor 3-Modify cooking

11. If you ate chicken, how often did you have it fried?
12. If you ate fish, how often did you have it fried?
13. If you ate chicken, how often did you bake or broil it?
14. If you eat fish, how often do you have it baked, broiled, or poached?
15. How often did you pan fry foods?

Factor 4-Increase healthful foods

16. How often did you eat at least one serving of cereal a day?
17. How often did you eat dark bread?
18. How often did you eat at least 2 servings a day of vegetables like carrots, celery, corn, peppers, broccoli, etc.?
19. How often did you have at least 1 serving of fruit a day?
20. How often did you have fruit or vegetables as snacks?
21. How often did you have at least 3 servings a week of broccoli, cabbage, or cauliflower?
22. How often do you eat bread, rolls, or muffins made from whole grains (whole wheat, rye, pumpernickel)?

Excluded Item

23. How often did you reduce the amount of butter, margarine, or oil in a recipe to cut down on fat?

Table 2. Overall characteristics of participants (N=1366)

Characteristic	Mean	Standard Deviation
Age (years)	43.9	6.0
Height (inches)	66.6	3.9
Weight (pound)	167.7	41.1
BMI	26.6	5.2
Education (years)	14.5	2.9
	% With characteristic	
Female	62.2	
Employed	86.3	
White	93.8	
Married	76.1	
General health = "Good" or better	89.1	

Table 3. Descriptive statistics of 2 samples

Characteristic	Sample 1 (N=683)		Sample 2 (N=683)	
	Mean	Standard Deviation	Mean	Standard Deviation
Age (y)	43.7	5.8	44.2	6.2
Height (in)	66.6	3.9	66.6	4.0
Weight (lb)	166.7	40.8	168.6	41.4
BMI	26.2	5.1	26.5	5.3
Education (y)	14.5	3.0	14.5	2.7

Table 4. Rotated component matrix using sample 1

Item	Components				
	Substitute	Moderate fat intake	Modify cooking	Fruits & Vegetable	Bread
1	0.62				
2	0.72				
3	0.69				
4	0.72				
5	0.70				
6		0.77			
7		0.62			
8	0.44	(0.21)			
9		0.75			
10	0.65	(0.22)			
11			0.71		
12			0.68		
13			0.62		
14			0.60		
15			0.64		
16				0.43	
17				(0.22)	0.83
18				0.61	
19				0.79	
20				0.77	
21				0.44	
22				(0.13)	0.86

52.1% of variance explained

Note: Low loadings for items identified in the original study as belonging to a specific component are shown in parentheses.

Table 5. Rotated component matrix using sample 1 with 4 factors setting

Item	Components			
	Substitute	Moderate fat intake	Modify cooking	Increase healthful foods
1	0.62			
2	0.72			
3	0.69			
4	0.72			
5	0.70			
6		0.76		
7		0.62		
8	0.44	(0.22)		
9		0.75		
10	0.65	(0.23)		
11			0.72	
12			0.65	
13			0.63	
14			0.59	
15			0.65	
16				0.47
17				0.71
18				0.55
19				0.60
20				0.61
21				0.52
22				0.66

46.6% of variance explained

Note: Low loadings for items identified in the original study as belonging to a specific component are shown in parentheses.

Table 6. Rotated component matrix using sample 2

Item	Components					
	Substitute	Moderate fat intake	Modify cooking	Healthful food 1	Healthful food 2	Bread
1	0.61					
2	0.64					
3	0.65					
4	0.74					
5	0.70					
6		0.72				
7		0.73				
8	0.42	(0.31)				
9		0.75				
10	0.64	(0.15)				
11			0.71			
12			0.68			
13			0.62			
14			0.60			
15			0.64			
16				0.68	(-0.08)	
17				(0.14)	(0.42)	0.83
18				(0.36)	0.63	
19				0.72	(0.20)	
20				0.72	(0.25)	
21				(0.03)	0.81	
22				(0.11)	(0.14)	0.84

56.1% of variance explained by 6 components

51.5% of variance explained by 5 components

Note: Low loadings for items identified in the original study as belonging to a specific component are shown in parentheses.

Table 7. Rotated component matrix using sample 2 with 4 factors setting

Item	Components			
	Substitute	Moderate fat intake	Modify cooking	Increase healthful foods
1	0.64			
2	0.60			
3	0.65			
4	0.75			
5	0.71			
6		0.69		
7		0.67		
8	0.40	(0.29)		
9		0.71		
10	0.60	(0.21)		
11			0.78	
12			0.64	
13			0.58	
14			0.52	
15			0.66	
16				0.44
17				0.54
18				0.62
19				0.64
20				0.65
21				0.52
22				0.58

46.1% of variance explained

Note: Low loadings for items identified in the original study as belonging to a specific component are shown in parentheses.

Table 8. Summary of Multiple Sample Model Results

Construct	TLI	RMSEA	χ^2	df	$\Delta\chi^2$	Δdf
Pre-Action vs Post-Action Stage						
Congeneric	0.833	0.036	1093.83	400	—	—
Lambda-Invariant*	0.832	0.036	1150.09	418	56.26	18
Tau-equivalent*	0.828	0.037	1195.24	428	45.15	10
Parallel*	0.787	0.041	1456.14	453	260.9	25
Female vs Male						
Congeneric	0.878	0.036	1110.45	400	—	—
Lambda-Invariant	0.882	0.035	1130.54	418	20.09	18
Tau-equivalent	0.885	0.035	1142.21	428	11.67	10
Parallel*	0.886	0.035	1202.58	453	60.37	25

Note: TLI=Tucker & Lewis index

RMSEA=Root mean square error of approximation

* $p < 0.05$ in $\Delta\chi^2$

Table 9. Summary of Cheung and Renswold's method

Construct	CFI	ΔCFI	G-hat	$\Delta G-hat$	NCI	ΔNCI
Pre-Action vs Post-Action Stage						
Congeneric	0.856	—	0.956	—	0.776	—
Lambda-Invariant	0.848	-0.008	0.954	-0.002	0.765	-0.011
Tau-equivalent	0.841	-0.007	0.951	-0.002	0.755	-0.010
Parallel*	0.792	-0.049	0.937	-0.014	0.692	-0.063
Female vs Male						
Congeneric	0.894	—	0.955	—	0.771	—
Lambda-Invariant	0.894	0	0.955	0.000	0.770	-0.001
Tau-equivalent	0.893	-0.001	0.955	0.000	0.770	0.000
Parallel	0.888	-0.005	0.952	-0.002	0.760	-0.010

Note: CFI=Comparative Fit Index

G-hat=Gamma-hat

NCI=McDonals's Non-centrality Index

* $\Delta CFI < -0.01$, $\Delta G-hat < -0.001$ and $\Delta MFI < -0.02$

Table 10. Cronbach's alpha of 4 subcategories in 2 samples

Subcategory	Sample 1		Sample 2	
	Alpha	N of items	Alpha	N of items
Substitute	0.77	5	0.76	5
Moderate fat intake	0.62	5	0.63	5
Modify cooking	0.70	5	0.68	5
Increase healthful foods	0.72	7	0.71	7

Table 11. Descriptive statistics of 4 components of DBQ

Subcategory	Mean	SD	Min	Max	Skewness	Kurtosis
Substitute	2.800	1.028	1.000	5.000	0.108	-0.743
Moderate fat intake	3.217	0.701	1.200	5.000	0.019	-0.349
Modify cooking	4.048	0.690	1.200	5.000	-0.748	0.409
Increase healthful foods	3.310	0.740	1.000	5.000	-0.122	-0.204

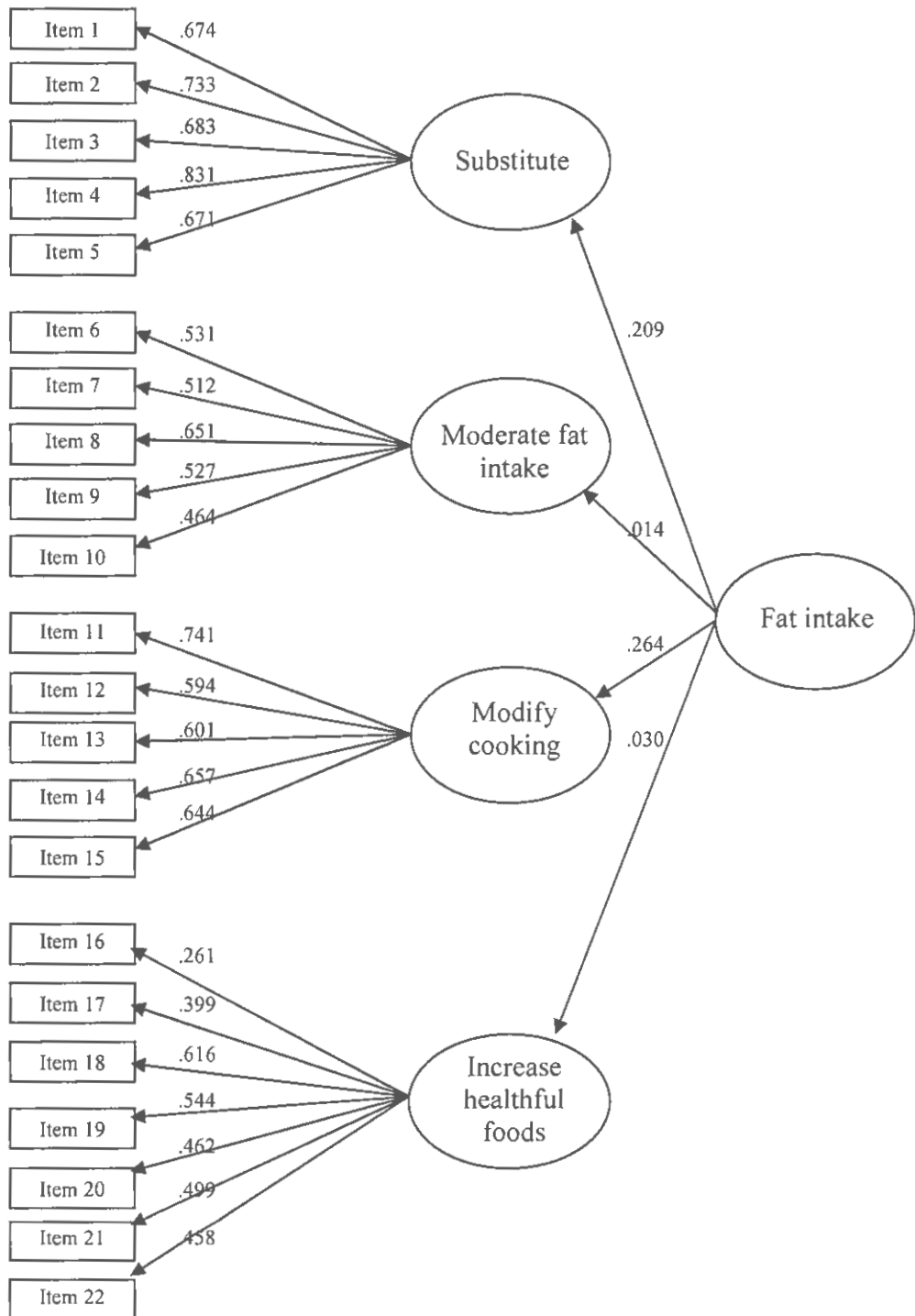
Table 12. ANOVA & Tukey test results for DBQ subcategories by stage of change

Subcategory	PC	C	PR	A	M	F(4, 1341)	η^2	Tukey test
	(n=575)	(n=115)	(n=269)	(n=38)	(n=349)			
	Mean (SD)							
Substitute	2.32 (0.88)	2.55 (0.83)	2.75 (0.82)	3.48 (0.96)	3.68 (0.86)	143.8*	0.30	PC, C, PR <A, M; PC < PR
Moderate fat intake	2.92 (0.62)	3.04 (0.62)	3.05 (0.53)	3.71 (0.55)	3.85 (0.54)	156.28*	0.32	PC, C, PR <A, M; PC < PR
Modify cooking	3.92 (0.73)	4.01 (0.65)	3.94 (0.68)	4.21 (0.68)	4.34 (0.54)	24.35*	0.068	PC, C, PR < M
Increase healthful foods	3.10 (0.72)	3.08 (0.69)	3.16 (0.62)	3.73 (0.68)	3.81 (0.62)	72.49*	0.18	PC, C, PR < A, M

*p<0.001.

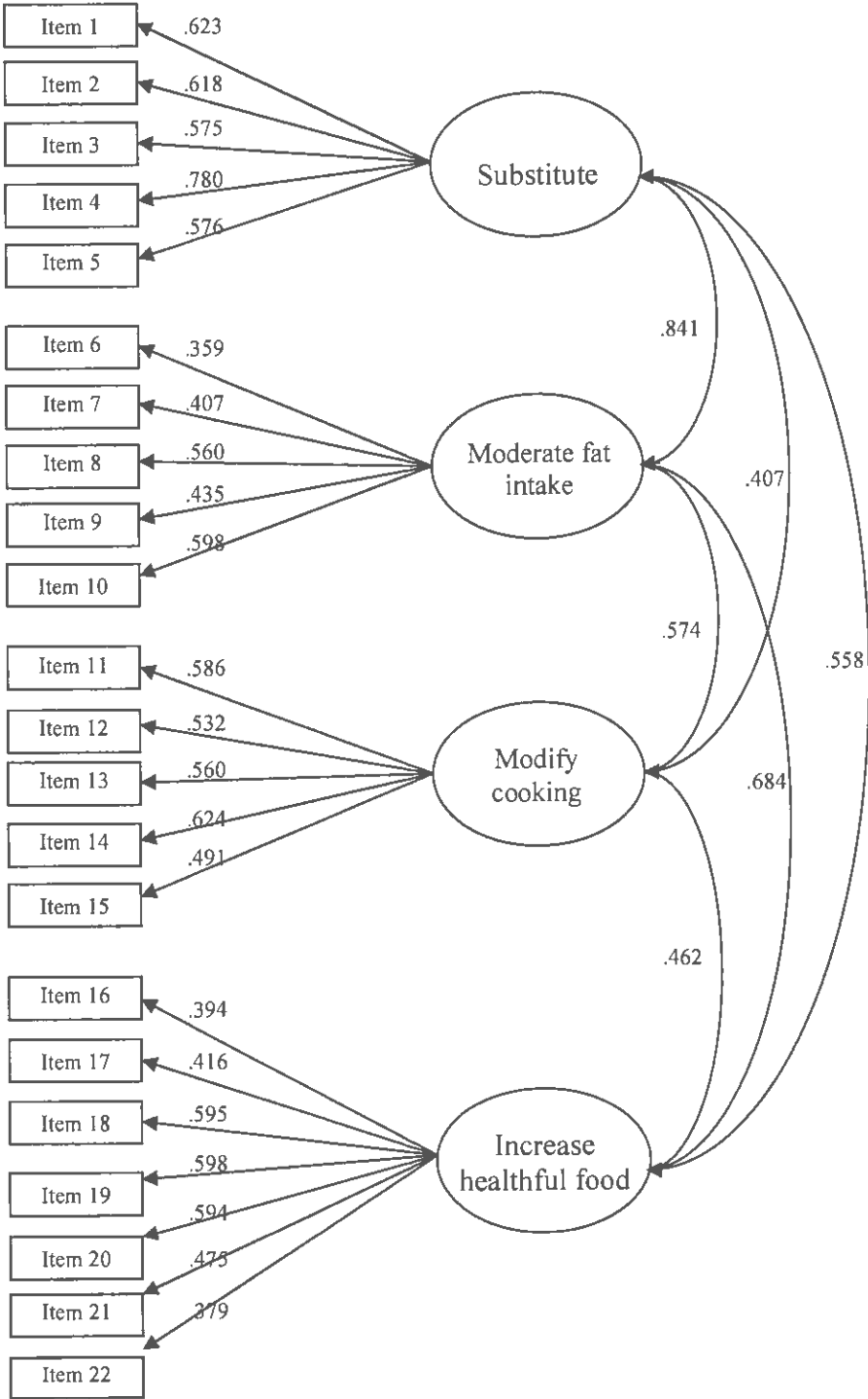
FIGURES

Figure 1. The original measurement model of DBQ



Note: This model has 4 correlation paths between the residuals of item 6 and 9 ($r=.369$), item 12 and 14 ($r=.268$), item 17 and 22 ($r=.515$) and item 19 and 20 ($r=.452$).

Figure 2. Final measurement model from CFA



Note: This model has 3 correlation paths between the residuals of item 6 and 9 ($r=.348$), item 17 and 22 ($r=.501$) and item 19 and 20 ($r=.352$).

Figure 3. The mean scores of 4 subcategories across the stages of change.

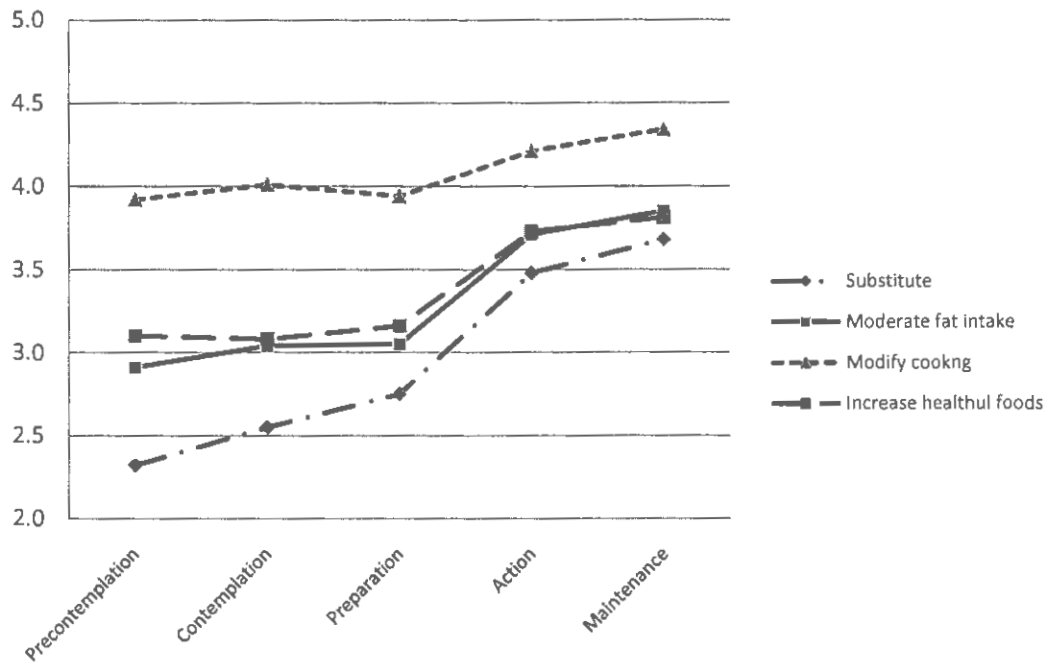


Figure 4. Residual plots of Modify cooking subcategory

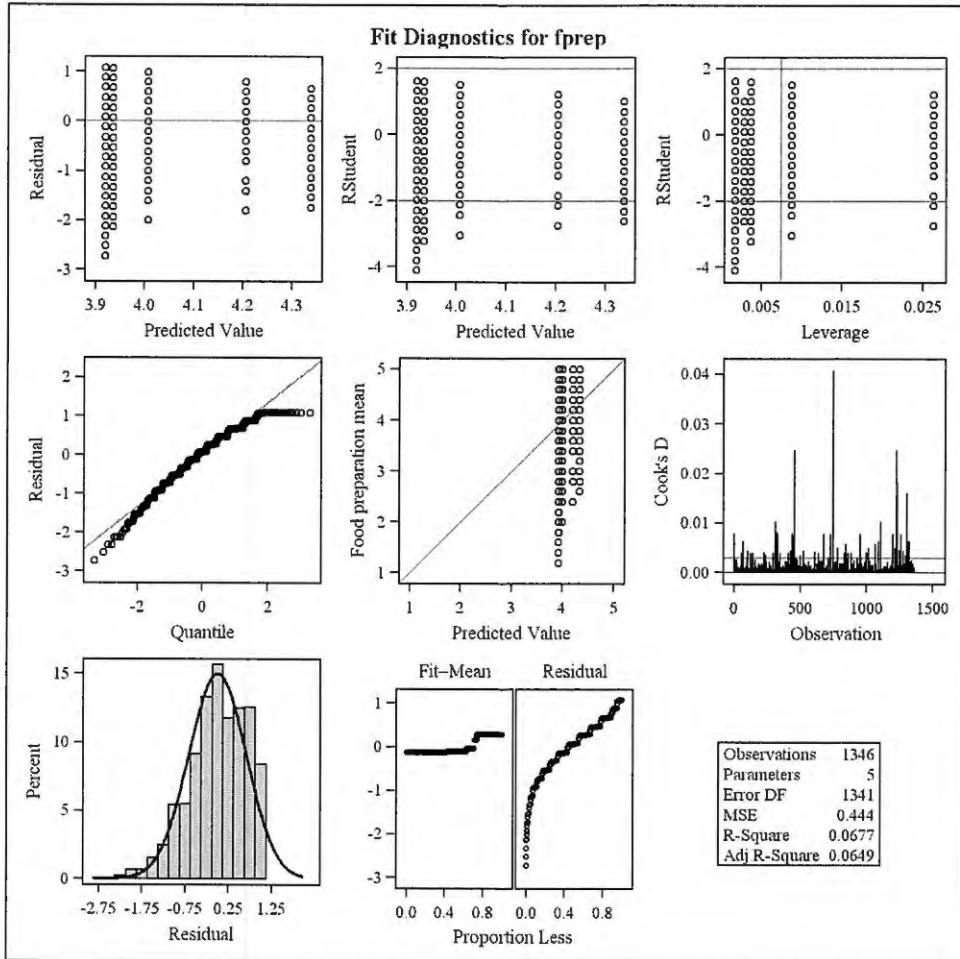


Figure 5. Residual plots of Moderate fat intake subcategory

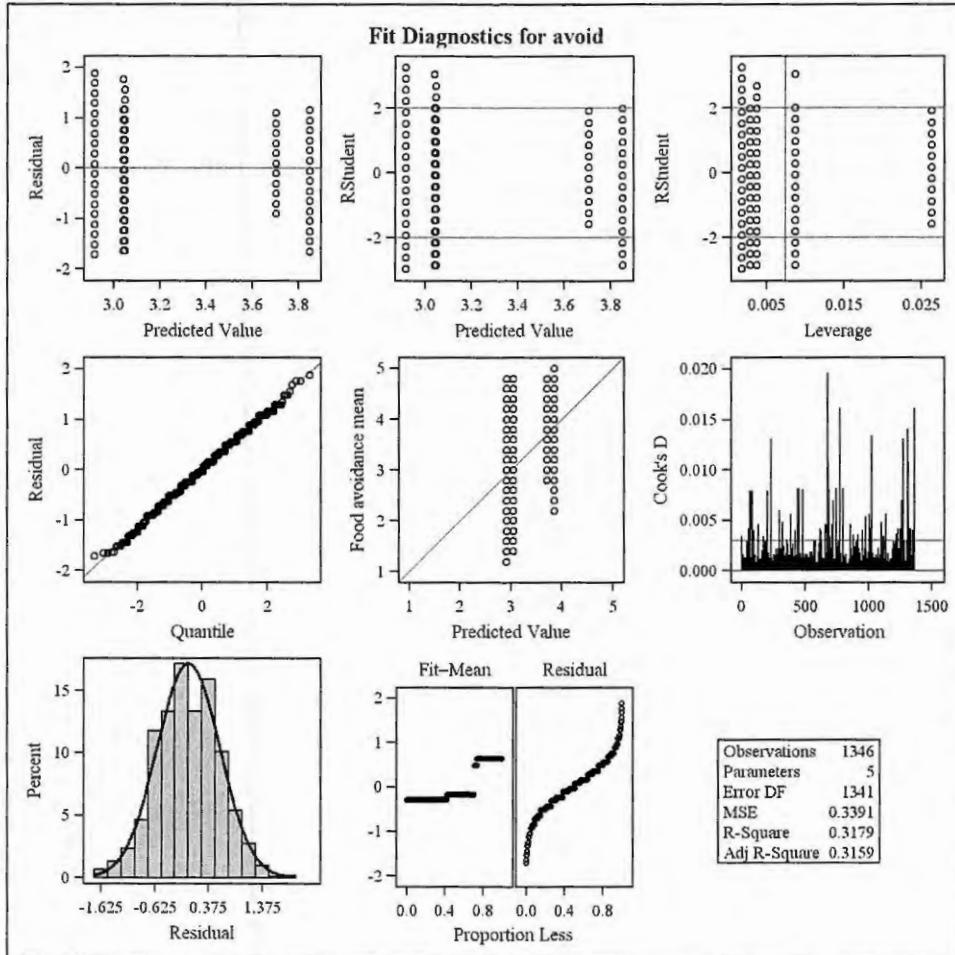
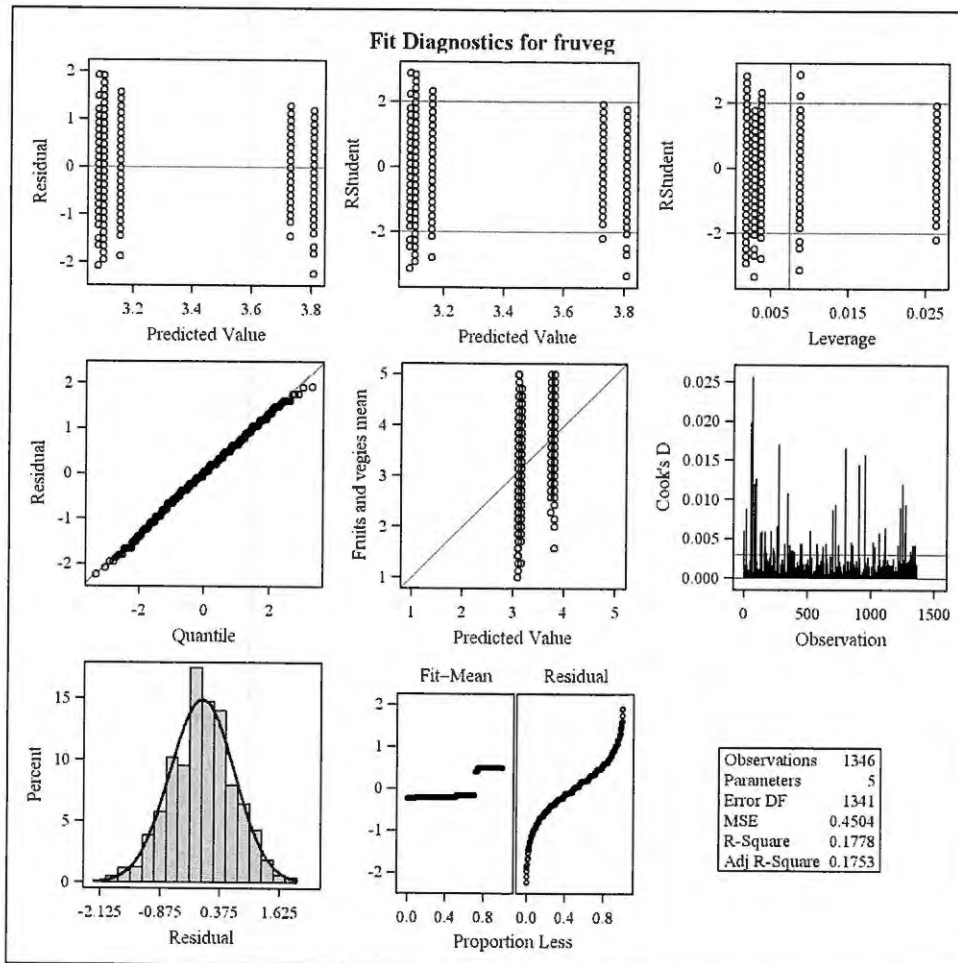


Figure 6. Residual plots of Increase healthy foods subcategory



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