BRAIN HEALTH PERCEPTIONS QUESTIONNAIRE: FURTHER DEVELOPMENT AND REFINEMENT

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BRAIN HEALTH PERCEPTIONS QUESTIONNAIRE:
FURTHER DEVELOPMENT AND REFINEMENT

BY

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The promotion of brain health is often perceived through an illness model, as research tends to focus on neurodegenerative disease risk reduction. However, research indicates that healthy individuals can potentially improve their cognitive performance through the adoption of health-promoting behaviors such as diet, exercise, and the management of cerebrovascular risk factors. There remains a need for validated instruments measuring the public’s perceptions about cognitive health, a need this study addressed by further refining a quantitative measure of brain health knowledge and beliefs, the Brain Health Perceptions Questionnaire (BHPQ). Principal Components Analysis resulted in a 23-item questionnaire composed of five subscales (Diet, Exercise, Type 2 Diabetes, Blood Pressure/Cholesterol, and Weight). Further analyses explored demographic group differences in levels of cardiovascular knowledge and brain health perceptions, and investigated the relationship between health behavior beliefs and self-efficacy. Analyses indicated that age is associated with level of cardiovascular health knowledge, but not with awareness of the link between lifestyle factors and brain health. Further, there appears to be a positive association between health behavior self-efficacy and knowledge of brain health; an association not demonstrated with cardiovascular health knowledge. These results suggest that there is a distinct relationship between confidence in one’s ability to engage in healthy lifestyle behaviors and one’s belief that such behaviors can improve overall brain health. Knowledge of such beliefs may inform clinical interventions and social policy, with the aim of reducing healthcare demand by supporting brain health across the lifespan.
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CHAPTER 1: Background

Introduction

It is important to conceptualize human health as both the reduction of disease and improvement of healthy functioning in all physical health domains. Health messages aimed at the general population often focus on the protection and promotion of cardiovascular and metabolic health, but focus less on brain health specifically. Brain health, and in particular the protection and improvement of cognitive functioning, is important for individuals of all ages. Unfortunately, research indicates that both younger and older adults appear to be unaware of methods to improve their brain health, and at times rely on poorly supported or potentially harmful treatments and strategies to improve and/or protect their cognitive functioning. This study further refined a brain health perceptions questionnaire with the goal of developing a quality instrument that can serve to inform future interventions.

Brain Health in Older Populations

A salient aspect of brain health for older adults is protection against cognitive decline. Research indicates the number of individuals struggling with neurocognitive disorders (including Vascular dementia and Alzheimer’s disease) will continue to increase. The number of patients diagnosed with Alzheimer’s disease, a debilitating neurodegenerative disorder that leads to dementia, is projected to increase, with approximately 13.9 million Americans expected to be diagnosed with the disease by 2060 (Matthews et al., 2019). In addition to major neurocognitive disorders, Mild Cognitive Impairment (MCI) has an estimated prevalence of 15-20% in individuals 60 or older
Concerned individuals have few options available when looking for pharmacological treatments to mitigate or protect against cognitive decline. Although medications exist to help slow decline in certain neurodegenerative disorders, they do not represent a cure. In a systematic review of the efficacy of common medications used to treat dementia, Buckley and Salpeter (2015) found that the efficacy of cholinesterase inhibitors decreased over time, reducing to only minimal benefit after just one year. Additionally, the researchers noted that pooled data from cholinesterase inhibitors showed improvements in the Mini-mental State Examination (MMSE) ranging from 0.8 to 1.6 points (out of 30 total); however, to be clinically significant, an improvement of 3 points or more is generally accepted (Buckley & Salpeter, 2015). Current setbacks in recent medication trials for diseases such as Alzheimer’s disease do little to offer hope for a cure in the near future (Cummings, Lee, Ritter, Sabbagh, & Zhong, 2019). Over the past 10 years a majority of phase III clinical trials for potential disease-modifying medications were discontinued after failing to meet their goals (Mehta, Jackson, Paul, Shi, & Sabbagh, 2017).

Additionally, a growing number of non-FDA recognized supplements provides consumers with false hope that they can improve their cognition and overall brain health through a simple pill. The use of pseudomedicine (e.g. the supplement Prevagen) to prevent and treat neurodegenerative diseases has risen in popularity, and is currently a $3.2 billion industry (Hellmuth, Rabinovici, & Miller, 2019). Although promotion of
such treatments is legal, and these supplements are advertised as being empirically supported, they lack credible supporting data (Hellmuth et al., 2019).

**Brain Health in Younger Populations**

The desire to improve cognitive functioning is not limited to clinical or at-risk populations. In younger populations, the focus is often on immediate cognitive improvements and performance enhancements. Unfortunately, some young adults utilize methods to improve their cognitive functioning that have potentially negative consequences, including stimulant-induced psychosis and/or mania, seizures, or cardiac arrhythmias (Cappelletti et al., 2018; Shibb & Chalhoub, 2009). Between 2006 and 2011, misuse of prescription stimulants among the adult population increased by about 67%; notably, ER visits resulting from stimulant misuse during this time rose 156% (Weyandt et al., 2016). A 2007 study reported stimulant misuse prevalence rates of 4.3% among adults aged 18-25, and 1.3% among adults aged 26-49 (Novak, Kroutil, Williams, & Van Brunt, 2007).

In addition to prescription stimulants, adults also report frequent caffeine use to help augment cognitive functioning. Sweeney, Weaver, Vincent, Arria, and Griffiths (2019) reported that 89% of Americans regularly consume caffeine; the authors also reported that among college students, caffeine use averages approximately 159-173 milligrams per day. Reasons cited for caffeine use included increased alertness, concentration and mood, as well as stress relief (Sweeney, Weaver, Vincent, Arria, & Griffiths, 2019). When used in moderation, caffeine is generally recognized as safe; however, caffeine dependence is recognized by the World Health Organization as a clinical disorder and caffeine dependence syndrome is recognized within the ICD 10
classification system (Meredith, Juliano, Hughes, & Griffiths, 2013). Furthermore, caffeine use is not suitable for certain at-risk populations (e.g. pregnant and nursing women, or patients with mental illness). Caffeine can also negatively interact with a range of medications (Temple et al., 2017).

**Current State of Brain Health and Perceptions**

Current research suggests that the adoption of healthy lifestyle factors, including a healthful diet, regular physical activity, and proper management of chronic medical conditions, can help protect and promote brain health or attenuate decline across many populations (Chang, Labbin, Gapin, & Etnier, 2012; Erickson et al., 2011; Martinez-Lapiscina et al., 2013; Petersson & Philippou, 2016; Strohle et al., 2015). Unfortunately, although it appears that the adoption of healthy lifestyle factors can support both physical health and brain health, most adults are not following recommended guidelines pertaining to proper nutrition and physical activity (Guiral, McAuley, Oberlin, Kramer, & Erickson, 2018). Specifically, although physical activity guidelines recommend 150-300 minutes per week of moderate-intensity aerobic activity for adults and 60 minutes daily for adolescents, only 20% of American adults and adolescents combined are achieving these guidelines (Piercy et al., 2018). Despite small improvements in American dietary patterns over the past decade, the percentage of calories obtained from low-quality carbohydrates and saturated fat still remain above recommendations, and only about 10% and 15% of Americans, respectively, are currently meeting whole grain and fruit/vegetable consumption guidelines (Korczak & Slavin, 2020; Shan et al., 2019, Van Horn, 2016).

Preliminary studies of brain health perceptions suggest that the public is only tenuously aware of the link between health behaviors and a decreased risk of developing
certain neurodegenerative diseases (Wu, Goins, Laditka, Ignatenko, & Goedereis, 2009). However, recent research indicates that highly-educated individuals appear to be increasing their awareness of the impact of lifestyle factors on brain health, when compared to those with less formal education (Budin-Ljøsne et al., 2022). Nevertheless, the American public as a whole is still underinformed on brain health and does not meet recommendations for healthful behavior.

**Theory Overview**

The field of behavior change research is wide and diverse, and includes health behaviors such as smoking cessation, physical activity, and healthy dietary patterns (Cox-Martin, Cox, Basen-Engquist, & Blalock, 2020; Hershey et al., 2019; McMahon et al., 2017). Researchers have developed multiple behavior change theories that seek to understand the motivations behind the adoption (or lack thereof) of certain health behaviors. Of these, I will discuss two prominent theories that informed the development of the BHPQ.

**Social Cognitive Theory**

Social Cognitive Theory (SCT) seeks to explain human behavior as a function of the interaction between personal, behavioral, and environmental influences, and the impact that certain factors have on self-regulation (Bandura, 1991). In addition to disease prevention, this model emphasizes health promotion. This shift in focus could potentially help reduce burden on the healthcare system by keeping individuals healthier throughout their life (Bandura, 1998). Within this model, the causal structure thought to help explain and initiate behavior change integrates self-efficacy beliefs, outcome expectations, and an individual’s perception of the value and personal significance of that behavior (Bandura,
1998). These factors all interact to further modulate self-regulation, a key component that directly relates to the initiation and maintenance of health behavior change (Bandura, 2005).

According to SCT, the concept of self-efficacy describes the level of power an individual feels they have over their own actions and their confidence in their ability to act in a self-regulative manner (Bandura, 1998). This level of power is crucial, as an individual is less likely to persevere in challenging situations if they feel powerless to change their behaviors (Bandura, 1998). Outcome expectations describe the beliefs that a specific behavior change will lead to either a desirable or undesirable consequence, and the expectations surrounding these changes. Another important consideration within SCT is the level of knowledge that an individual has regarding the potential health behavior change. Knowledge concerning the risks and benefits of a certain health practice can serve to influence an individual’s action as they consider any potential discomforts that might accompany the behavior change (Bandura, 2004).

**Transtheoretical Model**

According to the Transtheoretical Model (TTM), individuals progress through a series of stages when attempting to change their behavior (Prochaska & Velicer, 1997). Previous health behavior models had conceptualized behavior change as a discrete event, occurring during a very brief time. In contrast, the TTM postulates that behavior change occurs more gradually over a series of stages, often in a non-linear fashion (Prochaska, Redding, & Evers, 2008; Prochaska & Velicer, 1997). The fundamental concepts of the TTM includes five stages of change (SOC), ten processes of change, and an individual’s consideration of both the pros and cons of behavior change. Additionally, the TTM
includes the impact of both self-efficacy beliefs and temptation toward the relevant unhealthy behavior on behavior change (Prochaska et al., 2008).

The core of the TTM comprises the six stages of change: Precontemplation, Contemplation, Preparation, Action, Maintenance, and Termination (Prochaska & Velicer, 1997). An individual in the Precontemplation stage is not considering behavior change within the next 6 months; possible reasons include little to no knowledge concerning the relationship between the behavior and health promotion, or past failed attempts. (Prochaska et al., 2008). Individuals who have made the initial decision to change their behavior soon (i.e., the next 6 months) are in the Contemplation stage, as they are considering the results that might accompany a change in their behavior (Prochaska et al., 2008). An individual in the Preparation stage wants to change their behavior(s) in the short-term and has already laid the groundwork to help support their intended behavior change. Individuals in the Action stage have started engaging in observable behavior change within the past 6 months, and individuals in the Maintenance stage rely less on behavioral change processes and are less tempted to relapse into past behaviors and habits (Prochaska & Velicer, 1997). An individual is considered in the final stage, Termination, when the behavior change has become a permanent component of their lifestyle (Prochaska et al., 2008).

The TTM describes an individual’s progression through the stages of behavior change by means of any or all of the ten processes of change: consciousness raising, dramatic relief, self-reevaluation, environmental reevaluation, self-liberation, social liberation, counterconditioning, stimulus control, contingency management, and helping relationships (Prochaska et al., 2008). Certain processes relate to an individual’s self-
image; for example, self-reevaluation (a process in which an individual assess their self-image in the presence or absence of an unhealthy habit), or self-liberation, which describes an individual’s belief and commitment to change (Prochaska & Velicer, 1997). Other processes expand the focus to include the individual and their environment, such as stimulus control (when an individual adjusts their environment to better support their healthy lifestyle change), or contingency management, which describes the consequences an individual establishes when they engage in positive or negative behaviors (Prochaska & Velicer, 1997). These processes are utilized differentially depending on an individual’s current stage. For example, knowledge is a precondition for change; therefore, the consciousness raising process (which involves increasing an individual’s awareness of the potential outcomes relating to a certain behavior) would most likely benefit an individual during Precontemplation or Contemplation (Prochaska & Velicer, 1997).

Other important features of the TTM include decisional balance considerations and the relationship between self-efficacy and temptation. Decisional balance relates to an individual’s assessment of the various benefits and challenges that might arise when engaging in behavior change (Prochaska et al., 2008). For example, an individual in Contemplation might be less likely to adopt certain behaviors if they believe the cons far outweigh any perceived benefits. According to the TTM, self-efficacy is the confidence an individual has in their ability to resist temptation: that is, to resist the desire to engage in behaviors that work against desired behavior change (Prochaska et al., 2008).

**The Use of Behavior Change Models in Health Promotion Interventions**
Research indicates that interventions informed by the SCT and TTM can positively impact health promotion behaviors. Hallam and Petosa (2004) investigated the impact of a brief (4-week) SCT-based intervention on exercise behaviors and self-efficacy. The authors evaluated the effect of four 60-minute instructional sessions delivered over 2 weeks on levels of SCT variables and exercise behavior. Participants (N = 48) in Contemplation, Preparation, or Action per the TTM were placed into either the control or intervention group. The intervention consisted of instructional sessions focusing on a foundational aspect of SCT (e.g., increasing self-regulation skills, discussing expected outcomes, and dispelling exercise myths). The authors reported that the intervention group experienced increases in most of the measured SCT variables, whereas the control demonstrated a decrease. Notably, the treatment group experienced an increase in their outcome expectancy values and self-efficacy, whereas the control group’s levels in both variables decreased. The authors concluded that these results suggested that a relatively brief, instructional, SCT-based intervention could improve self-regulation, outcome expectancy values, and overall self-efficacy. In addition, these improvements were associated with an increased ability to maintain exercise habits.

Chapman-Novakofski (2005) investigated the impact of an education class designed to increase knowledge and self-efficacy concerning healthful dietary practices in a clinical population. Research participants (patients with diabetes, or their caregivers) completed pre- and post-program questionnaires addressing demographic variables, knowledge concerning general dietary factors, stage of change, and level of self-efficacy in diabetes dietary self-management. After participating in the program, participants (N = 239) demonstrated an improvement in nutrition knowledge and in self-efficacy beliefs
about engaging in healthful dietary habits (i.e. reading nutrition labels, preparing healthful meals, and controlling their total carbohydrate intake). Chapman-Novakofski (2005) further noted that in comparison to their baselines, participants tended to demonstrate progress towards more advanced stages of change (i.e. Action and Maintenance).

Additionally, computer-based health behavior change interventions informed by the TTM have demonstrated effectiveness in promoting healthful lifestyle changes. Jones et al. (2005) compared the impact of Pathways to Change (PTC), a computer-based, individually-tailored program focusing on promotion of healthy eating, glucose self-testing, and smoking cessation, to a treatment-as-usual control (TAU) group on stage progression for multiple health behaviors in patients with diabetes (Jones et al. 2005; Vallis et al., 2003). Results indicated that PTC demonstrated increased progression into action stages (e.g., Action and Maintenance) for diabetes self-care behaviors when compared to TAU (Jones et al., 2005). Meta-analyses further support the use of computer-based TTM interventions to assist individuals as they adopt multiple health behaviors associated with chronic diseases (Krebs et al., 2010). Indeed, computer-delivered TTM-based educational interventions appear to promote multiple simultaneous health behavior changes through the generalizability of skills learned in these programs (Krebs et al, 2010; Paiva et al., 2012). In addition to supporting self-care in patients with diabetes, TTM-based interventions likewise appear to help non-clinical individuals reduce specific unhealthy behaviors such as smoking or consumption of high fat diets (Prochaska et al., 2004; Prochaska et al., 2005).
In addition to promoting positive behavior change for patients with diabetes, educational, computer-based interventions show promise for promoting brain health behavior engagement. For example, the Gray Matters multi-domain pilot trial, developed using the TTM as a theoretical foundation, engaged participants in healthy lifestyle changes to reduce risk of Alzheimer’s disease in healthy middle-aged adults (Norton et al., 2015). Through an app, participants were provided with evidence-based information (e.g., “Consuming high amounts of processed foods is related to cognitive decline”) and suggestions regarding lifestyle changes to reduce their risk of developing Alzheimer’s disease, in addition to weekly feedback about their progress in specific behavioral domains (i.e., physical activity, diet quality, social engagement, cognitive stimulation, stress management, and sleep quality) (Hartin et al., 2016; Schiwal, Fauth, Wengreen, & Norton, 2020). Interviews with participants conducted after six months indicated that the information and feedback provided through the app were associated with higher motivation to perform physical activity and to follow a healthy diet in over 85% of the participants (Hartin et al., 2016). As Norton et al. (2015) noted, few studies have investigated the impact of multi-domain behavior change on the promotion of brain health. Based on interventions developed using the TTM for similar complex medical conditions (e.g., diabetes), interventions informed by health behavior change models show promise in supporting individuals as they engage in behavior change to support their overall brain health.

**Study Aims**

Behavior change is a complex, multifactorial process that incorporates the effect of awareness, knowledge, time, barriers and facilitators, and individuals’ expectations
and evaluations of their own actions. As Bandura (1998) cautioned, as our population ages and increases strain on healthcare resources, we need to focus on reducing demand. Similarly, because the number of individuals diagnosed with neurodegenerative disorders is expected to increase, specific health behavior interventions are needed to both protect and improve brain health and reduce the risk of cognitive decline. Interventions informed by both the TTM and SCT can help promote brain-health behavior changes and keep brains healthier across the lifespan.

The current study expanded on this author’s previous work developing the Brain Health Perceptions Questionnaire (BHPQ), which assesses participants’ level of knowledge in key areas of brain health and lifestyle factors. Such a questionnaire, which assists in better understanding the general public’s knowledge and perceptions about brain health and lifestyle can, in turn, help in designing and assessing targeted interventions. Additionally, the current study aims to add to the literature regarding awareness of brain health factors by conducting initial exploratory analyses regarding the relationship between knowledge of brain health, cardiovascular health, and health behavior self-efficacy.

**Research Questions and Hypotheses**

1. What is the underlying structure of the BHPQ?

Hypothesis: Development of the BHPQ focused on items that pertained to three main areas of brain health promotion and prevention: diet, physical activity, and chronic medical conditions (ie., Type 2 diabetes, hypertension, hyperlipidemia, and weight management). Therefore, exploratory factor analysis will result in a three-factor structure with correlated factors.
2. Are there differences in how the general public views brain health, as opposed to cardiovascular health?

Hypothesis: As similar health and lifestyle factors impact both cardiovascular and brain health, there will be a positive correlation between measures of brain health knowledge and cardiovascular health knowledge. Regarding specific demographic differences, based on previous research indicating that older adults tend to believe that neurodegenerative disorders such as Alzheimer’s disease is preventable (Anderson, McCaul, & Langley 2011), I anticipate that older adults will have higher scores on the BHPQ (indicating greater endorsement of the impact of modifiable lifestyle factors and health conditions on brain health) when compared to younger cohorts.

3. Is there an association between level of health behavior self-efficacy and brain health and cardiovascular health knowledge?

Hypothesis: Given that brain health and cardiovascular health are based on similar factors, both brain and cardiovascular health will have similar correlations with health behavior self-efficacy.
CHAPTER 2: Methods

Design

The study utilized a quantitative questionnaire refinement method (exploratory factor analysis) using data from initial pilot testing with a sample of participants from the general U.S. population.

Procedures

Participants completed the Brain Health Perceptions Questionnaire (BHPQ), the Heart Disease Fact Questionnaire (HDFQ) (Wagner et al., 2005), the Exercise Self-Efficacy Scale (Kroll et al., 2007), and the healthy eating subscale of the Healthy Eating and Weight Self-Efficacy Scale (HESE) (Wilson-Barlow et al., 2014). Additionally, participants completed demographic questions pertaining to age, education, gender identity, race/ethnicity, and the U.S. region in which they live. The survey was administered in English.

Measures

The Brain Health Beliefs Questionnaire (BHPQ)

The BHPQ (Ogram Buckley, 2019) is a 33-item questionnaire developed to measure the general public’s perceptions about specific aspects of brain health. Specifically, the original questionnaire includes 33 items; 10, 12, and 11 items assessing perception regarding the impacts of nutrition, exercise/physical activity, and chronic medical conditions, respectively, on brain health promotion and disease prevention. Questionnaire development involved three stages: first, I developed items based on recent meta-analytic studies of individual brain health factors (e.g., physical activity and nutrition). Upon development of the initial 49 items, University of Rhode Island undergraduate students participated in cognitive interviewing to further refine items to
address areas of misunderstanding that may negatively impact response quality. After initial item refinement, experts in the field of brain health and lifestyle factors provided feedback about item content and clarity. Following review of the feedback, questionnaire refinement resulted in the 33-item version used to address research question one in the current study. Each item is rated on a 4-point scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). A total score is calculated by summing all 33 items. A higher score indicates a greater belief in the positive impact of certain lifestyle factors and cardiovascular health on brain health.

**Heart Disease Fact Questionnaire (HDFQ)**

The purpose for including the HDFQ (Wagner et al., 2005) was to evaluate the BHPQ’s construct validity, and to compare the general public’s perceptions of brain health and cardiovascular health. The HDFQ is a 25-item (true/false) questionnaire that evaluates knowledge of primary risk factors for developing coronary heart disease; the number of correct responses is the total score (Wagner et al., 2005). During initial development, Wagner et al. (2005) administered the HDFQ to 524 participants to evaluate psychometric properties. The HDFQ demonstrated good internal consistency (Kuder-Richardson-20 coefficient = .77) (Wagner et al., 2005). Sample items from the HDFQ include: “Diabetes is a risk factor for developing heart disease,” and “Regular physical activity will lower a person’s chance of getting heart disease.” See Appendix A for the full questionnaire.

**Healthy Eating and Weight Self-Efficacy Scale (HEWSE)**

The HEWSES is an 11-item questionnaire that addresses beliefs surrounding one’s ability to engage in behaviors that promote healthy food consumption and weight
maintenance (Wilson-Barlow et al., 2014). The items comprise two subscales (seven items on the consumption of healthy foods subscale, and four items on the healthy weight subscale) and are rated on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). Confirmatory factor analysis on the 11-item scale supported the two-factor structure previously established through factor analysis ($CFI = .95$, $RMSEA = .06$, 95% CI (.03, .08) (Wilson-Barlow et al., 2014). The total questionnaire demonstrated good internal consistency ($\alpha = .82$), as did the consumption of healthy foods subscale ($\alpha = .81$) and the healthy weight subscale ($\alpha = .82$). For the purposes of the current study, the consumption of healthy foods subscale was included as a measure of healthful diet self-efficacy (referred to as HESE), as this subscale has been used independently in previous studies to measure nutritional self-efficacy (Boedt et al., 2021); (Dijksterhuis et al., 2021); (Dumitrescu & Iacob, 2021). Items from this subscale include: “I am able to consume fruits and vegetables in most of my meals,” and “I am able to eat a variety of healthy foods to keep my diet balanced.” See Appendix B for the full questionnaire.

**Exercise Self-Efficacy Questionnaire (ESES)**

The ESES is a 10-item questionnaire designed to measure confidence in one’s ability to engage in physical activity independently (Kroll et al., 2007). Participants rate each item on a four-point scale (1 = not at all true, 4 = always true). The scale demonstrated high internal consistency ($\alpha = .93$) during initial development studies among 368 patients with spinal cord injury (Kroll et al., 2007), and with hemodialysis patients ($\omega = .70$) (Hatef et al., 2018). Sample items include: “I am confident that it is easy for me to accomplish my activity and exercise goals,” and “I am confident that I
could find the means and ways to exercise and be physically active.” See Appendix C for the full questionnaire.

**Participants and Recruitment**

I collected survey data using the Prolific survey distribution platform; participants were registered site users who opted-in to take the survey. Exclusion criteria were age and location; only participants 18 and older who identified as United States nationals were eligible for the study. I did not adopt any additional exclusion criteria due to the exploratory nature of this pilot study; however, as discussed below, I excluded cases based on inconsistent responding after concluding data collection.

Literature provides inconsistent guidance regarding sample size determination for the primary analysis of the study (exploratory factor analysis) (Williams, Onsman, & Brown, 2010). Common estimates range from 100 to 500 participants, although other articles state that subject pools of 1,000 or greater are required when using EFA in questionnaire refinement (Comrey, 1973). In contrast, Sapnas and Zeller (2002) report that a sample size of 50 to 100 participants can be adequate for EFA, noting that “sample size overkill” can result when researchers attempt to follow certain sample size estimation guidelines (e.g. requiring 10 participants per item). Likewise, De Winter, Dodu, and Wieringa (2009) state that an EFA with quality data can yield reliable results with a sample size as small as 50 participants. Taking these guidelines into consideration, the current study recruited 300 participants to maximize sample size given available resources.

**Data Analysis**

*Data Quality Review*
Prior to conducting the main statistical analyses, I reviewed the data for response consistency by comparing four pairs of matched items. As each pair consisted of mutually exclusive statements (e.g., “Regularly eating foods high in added sugar can increase the risk of developing dementia,” and “Regularly eating foods high in added sugar has no impact on the risk of developing dementia”), agreeing to both items raised concern about poor item engagement or attention as it constitutes a logical incompatibility. Therefore, if a participant indicated “agree” or “strongly agree” to both items in at least two pairs, their responses were not included in the analyses. I did not exclude cases in which participants indicated disagreement for both items, as such a disagreement might result from belief that the items are unrelated, or may result from a surprising belief (but not one that constitutes an incompatibility of belief). In total, 14 participants were removed through consistency analyses, thereby reducing total sample size to 286.

**Questionnaire Refinement: Exploratory Factor Analysis**

All statistical analyses were performed using SPSS version 27.0 (IBM, 2020). To provide guidance for how many factors should be extracted, I first conducted the Minimum Average Partial (MAP) procedure (Velicer, 1976) prior to the EFA. I also reviewed the Scree plot, a graphical depiction of the percent of variance explained by each factor, to further clarify the approximate number of factors to retain (Cattell, 1966).

To address research question one, I conducted an EFA with principal components extraction and promax rotation, as this oblique extraction method is recommended when factors are presumed to be correlated with one another (Sass & Schmitt, 2010). Only cases with all available variables for the BHPQ were included in the analysis (n = 261). I
reviewed component loadings following the classification guidelines Comrey and Lee (1992) proposed: loadings of 0.70 and above are considered excellent, 0.63 is very good, 0.55 is good, 0.45 is fair, and 0.32 is minimal. Per these classifications, any items with loadings below 0.63, or items with significant loadings on at least two factors, were removed (Comrey & Lee, 1992); (Meyers et al., 2013). I repeated this process until no items fit the removal criteria, and the number of components retained was consistent with the estimation provided by the MAP procedure and visual review of the Scree plot.

After removal of items with low loadings and determination of the final components that comprise the BHPQ, I calculated reliability coefficients per component and for the full questionnaire. To evaluate initial evidence for convergent validity, the BHPQ and the HDFQ were placed within an intercorrelation matrix, as both brain and cardiovascular health are based on similar risk-reduction and health-promotion factors. As research is still sparse regarding the strength of the relationship between brain health knowledge and cardiovascular health knowledge, for the purposes of this study, a moderate positive correlation (i.e., \( r \geq .30 \)) will be viewed as providing tentative evidence for the BHPQ’s convergent validity. Lastly, I calculated descriptive statistics, internal consistency, and measures of normality for all questionnaires (BHPQ, HDFQ, HESE, and ESES).

**Exploration of brain and cardiovascular health knowledge differences**

To address research question two and investigate demographic group differences between brain health knowledge and cardiovascular health knowledge, a one-way analysis of variance (ANOVA) was conducted per demographic variable for the BHPQ.
To investigate group differences for the HDFQ, I utilized the Kruskal-Wallis test, as initial analyses yielded issues with normality for this specific measure.

_Investigation of relationship between self-efficacy and health behavior knowledge_. To investigate the relationship between health factor knowledge and self-efficacy for health behaviors, I first calculated an intercorrelation matrix for the BHPQ, HDFQ, ESES, and HESE. Then, to further explore any potential group differences in knowledge between level of health-behavior self-efficacy and health knowledge, I developed groups for the independent variable by determining what total scores of the self-efficacy questionnaires were closest to a z score of +/- .67 for the sample, and used those scores as cutoffs between low, medium, and high self-efficacy. As MANOVA is robust against violations of the normality assumption not due to outliers and in the presence of generally equal group sizes, I performed MANOVAs with the BHPQ and HDFQ as the dependent variables and low, medium, and high levels of self-efficacy as the independent variable groupings for both the HESE and the ESES.
CHAPTER 3: Results

Sample Characteristics and Initial Analyses

I initially reviewed responses for each member of the total sample (n = 300) for data quality. After removal of cases identified as inconsistent responders (n = 14), I then calculated descriptive statistics for the sample demographics including age, level of education, gender identity, geographic location in the U.S., and racial/ethnic identity. As can be seen by examining Table 1, the sample represented individuals from multiple racial/ethnic backgrounds: White (77.62%); Asian American (8.04%); Multiracial (5.24%); Black or African American (4.55%); and Hispanic or Latino (4.55%). The sample consisted of about 57% women and 42% men, with a few individuals indicating other gender identities. A majority of the sample was at least college-educated: Associate degree (10.14%); Bachelor’s degree (40.91%); Master’s degree (11.54%), or a Doctorate (4.9%). The remainder of the sample had either a high school diploma/GED (14.34%) or had enrolled in college classes but did not earn a degree (18.18%). In total, 63% of participants were middle aged (i.e., 30-59 years old), with 31% and 6% of the sample consisting of younger and older adults, respectively. The sample was generally equally split based on participant’s location within the United States. Additionally, I examined normality for the supplementary measures: HDFQ, ESES, and HESES. The Shapiro-Wilk test indicated that all three measures were not normally distributed (p < .05), although skewness and kurtosis values fell broadly within the acceptable range for the ESES (skewness = -.91, kurtosis = 1.02) and the HESES (skewness = -.95, kurtosis = .47).
Table 1

Demographic Characteristics of Sample

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age Groups</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young Adult</td>
<td>88</td>
<td>31%</td>
</tr>
<tr>
<td>Middle Aged Adult</td>
<td>180</td>
<td>63%</td>
</tr>
<tr>
<td>Older Adult</td>
<td>18</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Highest level of education completed:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School/GED</td>
<td>41</td>
<td>14%</td>
</tr>
<tr>
<td>1-3 years college (no degree earned)</td>
<td>52</td>
<td>18%</td>
</tr>
<tr>
<td>Associate degree</td>
<td>29</td>
<td>10%</td>
</tr>
<tr>
<td>Bachelor's degree</td>
<td>117</td>
<td>41%</td>
</tr>
<tr>
<td>Master's degree</td>
<td>33</td>
<td>12%</td>
</tr>
<tr>
<td>Doctorate (e.g., MD, PhD, PsyD, EdD)</td>
<td>14</td>
<td>5%</td>
</tr>
<tr>
<td><strong>What region of the United States are you currently living in?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>67</td>
<td>23%</td>
</tr>
<tr>
<td>Midwest</td>
<td>67</td>
<td>23%</td>
</tr>
<tr>
<td>West</td>
<td>57</td>
<td>20%</td>
</tr>
<tr>
<td>South</td>
<td>95</td>
<td>33%</td>
</tr>
<tr>
<td><strong>What is your gender identity?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Man</td>
<td>121</td>
<td>42%</td>
</tr>
<tr>
<td>Woman</td>
<td>162</td>
<td>57%</td>
</tr>
<tr>
<td>Non-binary or other gender designation</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td><strong>What is your race/ethnicity?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>222</td>
<td>78%</td>
</tr>
<tr>
<td>Black or African American</td>
<td>13</td>
<td>5%</td>
</tr>
<tr>
<td>Asian American</td>
<td>23</td>
<td>8%</td>
</tr>
<tr>
<td>American Indian/Alaskan</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Native</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native Hawaiian/Pacific</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Islander</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>13</td>
<td>5%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>15</td>
<td>5%</td>
</tr>
</tbody>
</table>

Note: Total percentages do not necessarily add up to 100% due to rounding.
Young adult = 18 - 29 years old
Middle Aged Adult = 30 - 59 years old
Older Adult = 60+ years old

Research Question 1: Survey Refinement

To address the first research question—*What is the underlying structure of the Brain Health Perceptions Questionnaire (BHPQ)?*—I performed an exploratory factor analysis.
(EFA) of the original BHPQ using data from general population participants recruited through Prolific. From an adjusted sample of 286 cases following removal of inconsistent responders, 25 additional individuals were removed through listwise deletion due to missing data. The Kaiser-Meyer Olkin measure of sampling adequacy was .92, indicating that the data were suitable for principal components analysis (Shrestha, 2021). Similarly, Bartlett's test of sphericity was significant ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis.

The MAP procedure for the first analysis indicated the presence of four components, and visual review of the Scree plot suggested five or six components. Unrestricted principal components extraction resulted in seven factors. See Table 2 for results of initial factor analysis and item loadings. I identified 16 items to remove: six items were consistency check items and not a part of the original questionnaire, seven items cross-loaded on multiple factors, and three items did not load strongly on any factors (removed items are indicated with an asterisk).

**Table 2**

*Structure Matrix: Initial PCA*

<table>
<thead>
<tr>
<th></th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
<th>Component 5</th>
<th>Component 6</th>
<th>Component 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having an unhealthy diet can increase the risk of developing dementia (a decrease in thinking abilities that leads to impairments in daily functioning) later in life.*</td>
<td>.489</td>
<td>.601</td>
<td>.602</td>
<td>.623</td>
<td>-.011</td>
<td>-.296</td>
<td>-.182</td>
</tr>
<tr>
<td>Eating a healthy diet may slow the decline in thinking abilities (for example, attention or memory) that comes with normal aging.*</td>
<td>.479</td>
<td>.603</td>
<td>.472</td>
<td>.692</td>
<td>-.115</td>
<td>-.271</td>
<td>.005</td>
</tr>
<tr>
<td>The Mediterranean diet (dietary pattern that is characterized by a low consumption of red meat, sweets, and saturated fat, and a high intake of fruits, vegetables, whole grains, and olive oil) can help reduce the risk of developing dementia later in life. The Mediterranean diet is good for brain health.</td>
<td>.383</td>
<td>.450</td>
<td>.372</td>
<td>.847</td>
<td>.074</td>
<td>-.251</td>
<td>.094</td>
</tr>
</tbody>
</table>
The Western diet (a dietary pattern that is characterized by a high consumption of red meat, processed and packaged foods, and sugar, and low intake of fruits and vegetables) is poor for brain health.*

Eating fruits and vegetables can reduce the risk of developing dementia.*

Regularly eating a lot of fruits and vegetables may slow the decline in thinking abilities that comes with normal aging.*

Regularly eating a lot of fruits and vegetables may help improve memory.*

Regularly eating a lot of fruits and vegetables may make it easier to pay attention to everyday activities, such as work tasks, reading or chores.*

Regularly eating foods high in added sugar can increase the risk of developing dementia.*

Regularly eating foods high in added sugar has no impact on the risk of developing dementia.*

Eating a healthy diet has no impact on any decline in thinking abilities that comes with normal aging.*

Exercise can improve thinking abilities in people with dementia.

Exercise can help make it easier to pay attention while doing everyday tasks, such as work tasks, reading, or chores.

Exercise can help people learn more easily.

Exercise can help many people improve their memory.

Exercise can help improve thinking abilities for younger adults (ages 18-29).

Exercise can help improve thinking abilities for older adults (ages 60 and older).

It is easier to pay attention right after exercising.*

Regular exercise can help improve memory abilities.

Regular exercise can slow down the loss of thinking abilities that can come with aging.

Exercise can help young adults (ages 18-29) improve their memory abilities.

Middle-aged adults (ages 30-59) can improve their memory abilities with regular exercise.

Staying active can help older adults delay decreases in memory that may come with aging.

Regular exercise can lead to forgetfulness.*

Exercise can harm thinking abilities in people with dementia.*

Some individuals with Type 2 diabetes (a medical condition in which the body does not use insulin properly to regulate blood glucose/sugar levels) might have reduced thinking abilities.

Having Type 2 diabetes can increase the risk of developing dementia later in life.

Some individuals with Type 2 diabetes might have reduced memory abilities.

Middle-aged adults (ages 30-59) with high cholesterol are more likely to get Alzheimer's disease later in life than middle-aged adults with normal cholesterol levels.

Middle-aged adults (Ages 30-59) with high cholesterol are more likely to lose some of their thinking abilities later in life.
Maintaining healthy blood pressure may slow the decline in thinking abilities that may come with aging.

Adults over 60 years old with high blood pressure are at greater risk for memory decline.

Middle-aged adults (30-59 years old) with high blood pressure are at greater risk for memory decline.

Being obese is associated with an increase in the risk of developing dementia later in life.*

Being obese is associated with having poorer attention.

Being obese is associated with having poorer memory.

Having Type 2 diabetes can decrease the risk of developing dementia later in life.*

After item removal, I re-ran the EFA (see Table 3). Results from the MAP test prior to the final round of EFA indicated the presence of about five factors. Evaluation of eigenvalues greater than one, and review of the Scree plot (see Figure 1), likewise indicated a five-factor structure, which accounted for 77.79% of the total variance.

**Figure 1**

*Scree Plot for final PCA*
The first subscale on the BHPQ contained 11 of the 12 items from the original Exercise scale, and accounted for approximately 50% of the variance. Reliability as measured by Cronbach’s $\alpha$ was .96. Examples of items on this subscale included:

“Exercise can help many people improve their memory,” “Regular exercise can slow down the loss of thinking abilities that can come with aging,” and “Exercise can improve thinking abilities in people with dementia.” Only one item was removed from the original scale: “It is easier to pay attention right after exercising.” The second and third factors contained all the original eight items pertaining to blood pressure, cholesterol, and Type 2 diabetes. The second factor, Blood Pressure/Cholesterol demonstrated strong internal consistency (coefficient $\alpha = .897$) and consisted of two cholesterol items (e.g., “Middle-aged adults (ages 30-50) with high cholesterol are more likely to lose some of their thinking abilities later in life.”), and three blood pressure items (e.g., “Maintaining healthy blood pressure may slow the decline in thinking abilities that may come with aging.”). Three items loaded on the Type 2 diabetes subscale (e.g., “Having Type 2 diabetes can increase the risk of developing dementia later in life,” and “Some individuals with Type 2 diabetes might have reduced memory abilities.”) which demonstrated strong internal consistency, coefficient $\alpha = .865$.

The fourth and fifth subscales consisted of two items each. The second subscale assessed knowledge pertaining to diet, and contained two of the original ten items from the Diet scale: “The Mediterranean diet (dietary pattern that is characterized by a low consumption of red meat, sweets, and saturated fat, and a high intake of fruits, vegetables, whole grains, and olive oil) can reduce the risk of developing dementia later in life,” and “The Mediterranean diet is good for brain health.” The Spearman-Brown
Coefficient was .892, indicating strong internal consistency. The third subscale was composed of two items from the original three Weight scale items, and likewise demonstrated strong internal consistency (Spearman-Brown Coefficient = .946): “Being obese is associated with having poorer attention,” and “Being obese is associated with having poorer memory.” Guidance from the literature is mixed regarding how to manage a factor that includes only two items, as it raises concern for poor estimation of a latent construct (Eisinga et al., 2013). However, as Eisinga (2012) and Raubenheimer (2004) indicate, two items can be acceptable for a subscale, although it is important to maximize internal reliability in these instances. As both two-item BHPQ subscales assess unidimensional constructs, and demonstrated Spearman-Brown Coefficients of .89 and .95, retention of these factors was judged to be advisable.

Table 3

Structure Matrix after removal of additional items

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Mediterranean diet (dietary pattern that is characterized by a low consumption of red meat, sweets, and saturated fat, and a high intake of fruits, vegetables, whole grains, and olive oil) can help reduce the risk of developing dementia later in life. The Mediterranean diet is good for brain health. Exercise can improve thinking abilities in people with dementia. Exercise can help people learn more easily. Exercise can help many people improve their memory. Exercise can help improve thinking abilities for younger adults (ages 18-29). Exercise can help many people improve their memory. Exercise can help improve thinking abilities for older adults (ages 60 and older). Regular exercise can help improve memory abilities. Regular exercise can slow down the loss of thinking abilities that can come with aging. Exercise can help young adults (ages 18-29) improve their memory abilities. Middle-aged adults (ages 30-59) can improve their memory abilities with regular exercise. Staying active can help older adults delay decreases in memory that may come with aging.</td>
<td>.945</td>
<td>.930</td>
<td>.843</td>
<td>.821</td>
<td>.847</td>
</tr>
</tbody>
</table>
Some individuals with Type 2 diabetes (a medical condition in which the body does not use insulin properly to regulate blood glucose/sugar levels) might have reduced thinking abilities.

Having Type 2 diabetes can increase the risk of developing dementia later in life.

Some individuals with Type 2 diabetes might have reduced memory abilities.

Middle-aged adults (ages 30-59) with high cholesterol are more likely to get Alzheimer's disease later in life than middle-aged adults with normal cholesterol levels.

Middle-aged adults (Ages 30-59) with high cholesterol are more likely to lose some of their thinking abilities later in life.

Maintaining healthy blood pressure may slow the decline in thinking abilities that may come with aging.

Adults over 60 years old with high blood pressure are at greater risk for memory decline.

Middle-aged adults (30-59 years old) with high blood pressure are at greater risk for memory decline.

Being obese is associated with having poorer attention.

Being obese is associated with having poorer memory.

The BHPQ demonstrated approximate normal distribution based on measures of skewness and kurtosis, (.09 and -.03 respectively); however, the Shapiro-Wilk test was significant ($p < .001$). Total scores ranged from 41 to 92 ($M = 70.88, SD = 10.20, 95\% \text{ CI} (69.64, 72.12)$). To obtain a measure of convergent validity, I examined the association between participants’ scores on the BHPQ and the HDFQ. A Pearson correlation coefficient generated a small positive result ($r = .20, p = 0.01$), which, although indicating a statistically significant relationship between the BHPQ and the HDFQ, does not fully support convergent validity. For additional correlations among all measures included in the study, see Table 4.
Table 4

Correlation matrix for measures

<table>
<thead>
<tr>
<th></th>
<th>BHPQ Total Score</th>
<th>HDFQ Total Score</th>
<th>ESE Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDFQ Total Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>267</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESE Total Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.291</td>
<td>.021</td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>&lt;.001</td>
<td>.725</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>272</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>HESE Total Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.186</td>
<td>.024</td>
<td>.514</td>
</tr>
<tr>
<td>p</td>
<td>.002</td>
<td>.688</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>n</td>
<td>272</td>
<td>273</td>
<td>280</td>
</tr>
</tbody>
</table>

Research Question 2: Comparison of Brain Health and Cardiovascular Health Knowledge

The second research question examined potential differences between the general public’s views on brain health versus cardiovascular health. As previously discussed, due to the HDFQ’s non-normal distribution and unequal groups within the demographic variables (see Table 1), I investigated univariate demographic group differences using the Kruskal-Wallis test for the HDFQ. Given the evidence of a normal distribution for the BHPQ as demonstrated by measures of skewness and kurtosis, as well as a visual review of the histogram (see Figure 2), I was able to conduct a one-way ANOVA for demographic group differences.
HDFQ total scores differed significantly in relation to age, $H(2) = 20.77, p < .001$. More specifically, post hoc pairwise comparisons revealed that young adults ($M = 22.18, SD = 2.01$) scored lower than middle aged adults ($M = 23.06, SD = 1.60, p < .001$) and older adults ($M = 23.41, SD = 1.33, p = .002$). There were no other significant group differences on any other demographic variable for HDFQ total scores: education [$H(5) = 8.47, p = .132$], US region [$H(3) = .39, p = .942$], gender identity [$H(2) = 5.72, p = .057$], or racial identity [$H(4) = 4.26, p = .372$].

A one-way ANOVA yielded no significant group differences in BHPQ scores for any demographic variables: age [$F(2, 272) = .63, p = .53, \text{partial } \eta^2 = .005$], education [$F(5, 269) = .46, p = .80, \text{partial } \eta^2 = .009$], US region [$F(3, 271) = .05, p = .98, \text{partial } \eta^2 = .001$], gender identity [$F(2, 272) = .86, p = .42, \text{partial } \eta^2 = .006$], or racial identity [$F(4, 270) = .27, p = .90, \text{partial } \eta^2 = .004$]. Levene’s test indicated unequal variances within the US region variable [$F(3, 271) = 4.51, p < .05$]; therefore, I ran an additional
Welch’s ANOVA, which likewise indicated no significant difference in BHPQ scores, $F(3, 136.41) = .07, p = .98$.

**Research Question Three: Self-efficacy and health knowledge**

The final research question addressed the possible association between level of diet and exercise self-efficacy and brain health and cardiovascular health knowledge. Analysis demonstrated a significant positive correlation between brain health knowledge and exercise self-efficacy (for reference, see Table 4) $[r(270) = .29, p = .01]$, and diet self-efficacy $[r(270) = .19, p = .01]$. There was no significant correlation between total cardiovascular knowledge and either diet self-efficacy or exercise self-efficacy.

**Exercise Self-Efficacy and Health Knowledge**

I conducted assessments of normality, outliers, linearity, homogeneity of variance-covariance matrices, and multicollinearity to evaluate for potential violations of the assumptions of MANOVA. After removal of univariate outliers identified by examining box plots ($n = 51$), I then assessed for multivariate outliers. Four cases demonstrated Mahalanobis distance values of greater than 13.82 (the critical chi-square value for two degrees of freedom at a critical alpha level of .001), and were subsequently removed from the analysis. Shapiro-Wilk tests indicated that the BHPQ was normally distributed in the low ESES group ($p = .49$); however, the average ESES and high ESES demonstrated non-normal distributions ($ps < .05$), as did all ESES levels for the HDFQ ($ps << .05$). Box’s $M$ test was not significant ($p = .56$), indicating that the observed covariance matrix of the dependent variables was equal across groups.
Table 5.

Descriptive Statistics for Exercise Self-Efficacy

<table>
<thead>
<tr>
<th></th>
<th>ESE by Groups</th>
<th>M</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHPQ</td>
<td>Low ESE</td>
<td>67.22</td>
<td>8.14</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Average ESE</td>
<td>69.76</td>
<td>7.15</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>High ESE</td>
<td>72.87</td>
<td>8.76</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>70.20</td>
<td>7.98</td>
<td>219</td>
</tr>
<tr>
<td>HDFQ</td>
<td>Low ESE</td>
<td>22.89</td>
<td>1.24</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Average ESE</td>
<td>22.99</td>
<td>1.39</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>High ESE</td>
<td>23.13</td>
<td>1.40</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>23.01</td>
<td>1.36</td>
<td>219</td>
</tr>
</tbody>
</table>

Results from the MANOVA indicated a statistically significant difference in health behavior knowledge between the exercise self-efficacy groups, Pillai’s Trace = .06, \( F(4, 432) = 3.15, p = .01 \), partial \( \eta^2 = .03 \), observed power = .82. Using a Bonferroni-corrected alpha procedure for two dependent variables, each ANOVA was tested at a .025 alpha level (see Table 7). There was a significant difference in brain health knowledge between the exercise self-efficacy groups, \( F(2, 216) = 6.49, p = .002 \), partial \( \eta^2 = .06 \), observed power = .90. Post hoc comparisons using Tukey’s HSD revealed that individuals in the high exercise self-efficacy group had significantly higher BHPQ scores \( (M = 72.87, SD = 8.75) \) than individuals in the average self-efficacy group \( (M = 69.76, SD = 7.15) \) and low self-efficacy group \( (M = 67.22, SD = 8.14) \). Additional descriptive statistics for high, average, and low self-efficacy groups are included in Table 5.
Diet Self-Efficacy

A one-way MANOVA was conducted to examine differences in health behavior knowledge (i.e., brain and cardiovascular health) between participants with low, medium, or high diet self-efficacy. I removed 45 univariate outliers after examining box plots; no multivariate outliers were observed as all Mahalanobis distance values were below 13.82. Shapiro-Wilk tests indicated that the BHPQ was normally distributed in the Low diet self-efficacy group ($p = .26$); however, the Average diet self-efficacy and High diet self-efficacy demonstrated non-normal distributions ($p < .05$), as did all HESES levels for the HDFQ ($p < .01$). Box’s $M$ test was significant ($p < .001$).

**Table 6.**

*Descriptive Statistics for Diet Self-Efficacy*

<table>
<thead>
<tr>
<th>DSE by Group</th>
<th>M</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHPQ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low DSE</td>
<td>67.62</td>
<td>7.92</td>
<td>55</td>
</tr>
<tr>
<td>Average DSE</td>
<td>68.00</td>
<td>4.82</td>
<td>94</td>
</tr>
<tr>
<td>High DSE</td>
<td>74.91</td>
<td>9.32</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>70.11</td>
<td>7.99</td>
<td>219</td>
</tr>
<tr>
<td>HDFQ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low DSE</td>
<td>22.84</td>
<td>1.08</td>
<td>55</td>
</tr>
<tr>
<td>Average DSE</td>
<td>23.03</td>
<td>1.39</td>
<td>94</td>
</tr>
<tr>
<td>High DSE</td>
<td>23.13</td>
<td>1.44</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>23.01</td>
<td>1.34</td>
<td>219</td>
</tr>
</tbody>
</table>

Results from the MANOVA indicated a statistically significant difference in health behavior knowledge between the diet self-efficacy groups, Pillai’s Trace = .18, $F(4, 430) = 10.38$, $p < .001$, partial $\eta^2 = .09$, observed power = 1.00. Following the Bonferroni procedure, each ANOVA was tested at a .025 alpha level (see Table 7). There was a significant difference in brain health knowledge between the diet self-efficacy groups, $F(2, 216) = 22.24$, $p < .001$, partial $\eta^2 = .17$, observed power = 1.00.
Post hoc analyses comparing BHPQ scores across the three levels of diet self-efficacy were conducted using the Dunnett C procedure due to violation of the assumption of homogeneity of variance. Post hoc analyses showed that individuals in the high diet self-efficacy group had significantly higher BHPQ scores ($M = 74.91, SD = 9.32$) than individuals in the average self-efficacy group ($M = 68.00, SD = 4.82$) and low self-efficacy group ($M = 67.62, SD = 7.92$). For additional descriptive statistics, see Table 6.

Table 7

*Results of Health Knowledge ANOVAs for Exercise and Diet Self-Efficacy*

<table>
<thead>
<tr>
<th></th>
<th>$F$</th>
<th>$p$</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise SE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BHPQ</td>
<td>6.49</td>
<td>0.002</td>
<td>0.06</td>
</tr>
<tr>
<td>HDFQ</td>
<td>0.39</td>
<td>0.679</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>Diet SE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BHPQ</td>
<td>22.24</td>
<td>&lt;.001</td>
<td>0.171</td>
</tr>
<tr>
<td>HDFQ</td>
<td>0.75</td>
<td>0.473</td>
<td>0.007</td>
</tr>
</tbody>
</table>

These results indicate that, although cardiovascular health knowledge and brain health knowledge are based on similar health promotion factors, only brain health knowledge is related to an individual’s level of confidence in their ability to engage in health-promoting behaviors. Further, individuals expressing high confidence in their ability to overcome barriers and maintain a healthy lifestyle appear to be more likely to believe in the positive impact of these lifestyle behaviors on brain health compared to individuals with lower health behavior self-efficacy.
CHAPTER 4: Discussion

Introduction

This study was designed to address a substantial gap in resources available for researchers and clinicians within the field of brain health behavior. To my knowledge, the BHPQ remains one of the few systematically developed questionnaires available that assesses brain health beliefs and perceptions. There remains a need for validated instruments measuring the public’s perceptions about cognitive health, in addition to those measuring perceptions regarding disease prevention (Anderson et al., 2009). The current study sought to address such needs by further refining a quantitative measure of perceptions regarding both cognitive decline prevention and brain health promotion. Additional aims included adding to knowledge about the BHPQ’s psychometric properties and performing preliminary analyses of the relationship between brain and cardiovascular health knowledge and health behavior self-efficacy.

Research Question 1: What is the underlying structure of the BHPQ?

To study the BHPQ’s underlying structure, I used EFA to assist in item reduction and subscale development, and also conducted an initial assessment of convergent validity. EFA reduced questionnaire length from 33 to 23 items, and resulted in five factors that accounted for 77.79% of the variance. These results supported my initial conceptualization of the BHPQ as a measure of participants’ perceptions regarding the influence of modifiable lifestyle factors on brain health; however, instead of my anticipated three-factor structure (Exercise, Diet, and Chronic Cardiovascular Conditions), the Chronic Cardiovascular Condition scale was divided into three specific components pertaining to individual elements of cardiovascular health (i.e., Type 2 Diabetes, Hypertension/Cholesterol, and Weight). Each subscale demonstrated strong
internal consistency (coefficient $\alpha$ ranging from .87 to .96 for subscales with greater than two items, and Spearman-Brown coefficients of .89 and .95 for two-item scales), as did the total questionnaire (coefficient $\alpha = .95$).

Initial investigation of convergent validity comparing the BHPQ with the HDFQ yielded a modest or low Pearson correlation coefficient ($r = .20$), and thus support for convergent validity was tenuous at best. However, it is important to note that the HDFQ was rated on a binary (true/false) scale, whereas the BHPQ items were rated on a four-point Likert scale; therefore, this variation between response styles could have potentially suppressed the correlation between the measures. Few well-validated questionnaires exist with which to appropriately assess the convergent validity of the BHPQ, as it is one of the first brain health perception instruments created using systematic questionnaire development procedures, such as cognitive interviewing, consultation of experts, and EFA refinement. The BHPQ will benefit from additional analyses of convergent validity, (particularly with measures utilizing multiple choice response formats), especially as the field of brain health behaviors expands and more brain health perceptions questionnaires become available.

**Research Question 2:** Are there differences in the general public’s views of brain health versus cardiovascular health?

To address this question, I investigated demographic group differences for the BHPQ and the HDFQ. The analyses yielded no significant differences in total brain health knowledge for any of the demographic variables (i.e., age, race/ethnicity, education, US region, or gender identity). In contrast, analyses resulted in significant group differences between total cardiovascular knowledge based on age, as both older
and middle-aged adults had higher total HDFQ scores than young adults (but with no significant differences obtained between older and middle-aged adults).

This lack of demographic group differences for brain health knowledge is intriguing, as it is not consistent with previous studies that have investigated the public’s perceptions about brain health. Anderson, McCaul, and Langley (2011) found age differences in brain health knowledge; notably, that older adults were more likely than younger adults to believe that modifiable lifestyle factors had an impact on the risk of developing AD. Likewise, Wilcox et al. (2009) conducted focus groups investigating themes of brain health behavior, and reported demographic differences in brain health perceptions. African American, American Indian, and Hispanic participants were less likely to agree that a link exists between physical activity and brain health than White, Chinese, or Vietnamese participants; additionally, American Indian and Hispanic participants were also less likely to endorse that a relationship exists between diet and brain health (Wilcox et al., 2009). Previous studies have also reported gender differences in brain health perceptions. Budin-Ljøsne et al. (2022) found that men were more likely than women to consider a healthful diet important for brain health. Additionally, education appeared to positively relate to brain health knowledge, as individuals with higher educational attainment were more likely to endorse physical health as a key factor in maintaining brain health (Budin-Ljøsne et al., 2022).

Although the current study found no significant differences between any demographic grouping in total brain health knowledge, a significant difference in cardiovascular health knowledge was demonstrated between age groups, as older age was associated with higher levels of cardiovascular health knowledge. This finding suggests
that older adults may be receiving more information and resources pertaining to promotion of their cardiovascular health given the association between cardiovascular disease and advancing age. Although older adults are at a greater risk for cognitive decline, perhaps brain health knowledge is broadly distributed and is not directly targeting one specific age demographic as precisely as cardiovascular health knowledge.

**Research Question 3: Is there an association between level of diet and exercise self-efficacy and brain health and cardiovascular health knowledge?**

To address this question, I investigated differences in brain and cardiovascular health knowledge between participants with high, medium, and low levels of health behavior self-efficacy. Analyses yielded significant differences in brain health knowledge between levels of self-efficacy. More specifically, individuals in the high exercise and diet self-efficacy groups demonstrated higher brain health knowledge when compared to individuals in the middle and low self-efficacy groups. No significant differences in cardiovascular health knowledge were observed for HDFQ total scores.

These statistically significant results, particularly the discrepant associations with self-efficacy, may suggest a difference between the public’s attitudes and awareness toward brain health and cardiovascular health. As Parker et al. (2018) observed, measures of health behavior self-efficacy may be a more accurate estimate of actual engagement in health behaviors than self-report measures of health behaviors. Indeed, as Parker et al. (2018) noted, such a link likely exists as self-efficacy often depends on an individual’s past successes and experiences. With this consideration in mind, the current study suggests that individuals who engage in health behaviors are more likely to be aware of the link between physical health and brain health when compared to those who
do not. A similar relationship was not demonstrated between cardiovascular knowledge and self-efficacy. As cardiovascular health knowledge is currently more widely disseminated within the general public, even those who do not regularly participate in health behaviors are most likely aware of the cardiovascular benefits of a healthy lifestyle. This may suggest that the current lack of widespread dissemination of brain health knowledge may disproportionately favor brain health awareness among individuals engaging in healthful behaviors, resulting in its association with self-efficacy.

Previous studies have found a similar association between brain health knowledge and engagement in health behaviors, but proposed the reverse causal direction. Smith et al. (2015) observed that individuals who are aware that health behaviors can reduce the risk of developing cognitive decline and who expressed confidence in their ability to reduce risk were more likely to report higher motivation and to act to improve brain health (Smith et al., 2015). In view of this line of thought, as the current study did not demonstrate an association between cardiovascular knowledge and self-efficacy, these discrepant associations may instead suggest that brain health outcome expectations exert a more motivating influence to initiate health behavior change than cardiovascular knowledge.

**Strengths and Limitations of the Current Study**

A significant strength of this study is a large sample size consisting of diverse participants. Indeed, the study sample included participants representing multiple ages, ethnicities, levels of education, gender identities, and US geographic regions. However, although these demographics were represented in the sample, it is important to consider
sample percentages. Notably, although the sample included individuals with varying levels of education, a majority (68%) of the sample was college educated and had earned at least an associate’s degree. The highly-educated nature of this sample may have therefore contributed to the lack of group differences observed in the demographic variables, and may also limit the generalizability of this study. As past research has indicated that higher education is associated with greater awareness of brain health (Smith, Ali, & Quach, 2015), the lack of significant findings in this current study may have resulted from the disproportionate number of highly educated participants. Likewise, the sample only included 18 adults over the age of 59 (6% of total sample), which may also misrepresent the beliefs and knowledge of older adults due to small sample size.

Additional considerations and limitations of the current study include the use of an online survey distribution platform, which recruits a sample with access to resources necessary to complete the survey. This method may under-represent disadvantaged or under-resourced populations, and results may not apply to members of a population at risk for low health-behavior engagement (Pampel et al., 2010). Additionally, this method increases the risk of selection bias, as participants who selected the survey from a list of available opportunities on Prolific may be more interested in (and therefore, potentially more knowledgeable about) brain health. However, the BHPQ did not demonstrate significant skewness, indicating a range of brain health beliefs that approximated a normal distribution. Another potential limitation is that the HDFQ demonstrated a non-normal distribution, which may negatively impact the utility of the linear methods used to analyze the data. To address this concern, I utilized multiple established procedures (e.g.,
removal of outliers, use of statistical methods robust to violations of normality) to improve the confidence in analyses using this questionnaire as a dependent variable.

**Future Directions and Conclusions**

The current study is a foundational step in a potential line of research investigating perceptions regarding brain health protection and promotion across healthy and at-risk populations. The BHPQ will benefit from additional validation studies of convergent validity (as the current study at best suggests the presence of modest convergent validity) as well as divergent validity. Future studies should focus on recruiting participants from a wider variety of populations, including clinical populations (e.g., individuals with acquired brain injury or mild cognitive impairment), in addition to expanding participation from groups under-represented in the current study (e.g., older adults and individuals with less than a college education).

Future developmental work on the BHPQ will address the four items comprising the current weight and diet subscales. As each of these subscales included only two items, they may instead be considered item couplets as opposed to traditional scales, and it may therefore be more appropriate to remove one item from each couplet and re-investigate the factor structure. Further, the weight scale consisted of items using weight-normative language (e.g., “Being obese is associated with poorer attention”), which may have unduly influenced participant responses, as weight-normative language is associated with the perception of “obesity” as a personal failing or shortcoming as opposed to a health concern (Zafir & Jovanovski, 2022). Future editions of the BHPQ will be revised to include neutral and person-centric language (e.g., “Maintaining a healthy weight may promote cognitive health at all ages”).
The current study may aid research about the impact of brain health intervention programs aimed at increasing brain health knowledge. Preliminary studies suggest a relationship between moderate to high levels of brain health knowledge and adoption of brain health promoting behaviors; however, results are somewhat inconsistent across investigations. A key element for future research in the burgeoning field of brain health behavior change may well be brain health behavior self-efficacy, as self-efficacy can link knowledge (a precondition for change) to engagement in desired health behaviors. To my knowledge, only one existent measure specifically addresses brain health self-efficacy (Gao et al., 2020), thus highlighting the pressing need for further investigation into this construct. The current study adds to the field of brain health behavior change by developing a questionnaire that assesses outcome expectations pertaining to engagement in specific lifestyle factors. As both outcome expectations and self-efficacy are crucial factors in health behavior change, the availability of systematically developed questionnaires that measure these constructs should facilitate investigations into the impact of brain health behavior change interventions on the adoption of health promoting behaviors.

Indeed, quantitative measures of brain health perceptions are invaluable, as this knowledge can more effectively inform public health policy regarding brain health promotion that aligns with the perceptions and daily experiences of the general public (Pelegrini, Lucas Nogueira de Carvalho et al., 2020). In addition to social policy, understanding brain health perceptions and their association with self-efficacy also has clinical utility on an individual level. For example, as Brands and van Heugten (2017) report, the development of self-efficacy for brain health behaviors should be a focus in
neuropsychological rehabilitation, as higher levels of both general self-efficacy and self-efficacy to manage symptoms of brain injury are associated with higher quality of life. Additionally, it may also be beneficial for clinicians across treatment settings to incorporate tailored patient recommendations based on which brain health behavior patients endorse as being likely to exert a positive impact on their brain health. Further, should the patient lack sufficient knowledge, recommendations may also focus on providing more comprehensive psychoeducation as an important foundational step. The BHPQ could give health providers individualized information regarding a patient’s brain health outcome expectations. This information may enable the selection of treatment recommendations that increase confidence in the ability to positively impact brain health through healthful lifestyle choices, and are thus more likely to result in adoption of brain health promoting behaviors.
Appendix A

Heart Disease Fact Questionnaire (Wagner, Lacey, Chyum, & Abbott, 2005)

1. A person always knows when they have heart disease.
2. If you have a family history of heart disease, you are at risk for developing heart disease.
3. The older a person is, the greater the risk of having heart disease.
4. Smoking is a risk factor for heart disease.
5. A person who stops smoking will lower their risk of developing heart disease.
6. High blood pressure is a risk factor for heart disease.
7. Keeping blood pressure under control will reduce a person’s risk for developing heart disease.
8. High cholesterol is a risk factor for developing heart disease.
9. Eating fatty foods does not affect blood cholesterol levels.
10. If your “good” cholesterol (HDL) is high you are at risk for heart disease.
11. If your “bad” cholesterol (LDL) is high you are at risk for heart disease.
12. Being overweight increases a person’s risk for heart disease.
13. Regular physical activity will lower a person’s risk for heart disease.
14. Only exercising at a gym or in an exercise class will lower a person’s chance of developing heart disease.
15. Walking and gardening are considered exercise that will help lower a person’s chance of developing heart disease.
16. Diabetes is a risk factor for developing heart disease.
17. High blood sugar puts a strain on the heart.
18. If your blood sugar is high over several months it can cause your cholesterol level to go up and increase your risk of heart disease.
19. A person who has diabetes can reduce their risk of developing heart disease if they keep their blood sugar levels under control.
20. People with diabetes rarely have high cholesterol.
21. If a person has diabetes, keeping their cholesterol under control will help to lower their chance of developing heart disease.
22. People with diabetes tend to have low HDL (good) cholesterol.
23. A person who has diabetes can reduce their risk of developing heart disease if they keep their blood pressure under control.
24. A person who has diabetes can reduce their risk of developing heart disease if they keep their weight under control.
25. Men with diabetes have a higher risk of heart disease than women with diabetes.
Appendix B

Healthy Eating and Weight Self-Efficacy Scale: Healthy Eating Subscale (Wilson-Barlow, Hollins, & Clopton, 2014)

1. I am able to consume fruits and vegetables in most of my meals.
2. I am able to eat a variety of healthy foods to keep my diet balanced.
3. Based on my knowledge of nutrition, I am able to choose healthy foods at restaurants and from stores.
4. I am able to modify recipes to make them healthier.
5. I am able to choose recipes based on nutritional value.
6. If I choose to indulge in unhealthy food, I am able to appropriately compensate later.
7. When I feel hungry, I am able to easily choose healthy food over less healthy options.
Appendix C

Exercise Self-Efficacy Scale (Kroll, Kehn, Ho, & Groah, 2007)

1. I am confident that I could always overcome barriers and challenges with regard to exercise if I try hard enough.
2. I am confident that I could find the means and ways to exercise and be physically active.
3. I am confident that it is easy for me to accomplish my activity and exercise goals.
4. I am confident that when I am confronted with a barrier to exercise I could usually find several solutions to overcome this barrier.
5. I am confident I could exercise even when I am tired.
6. I am confident I could exercise even when I am feeling depressed.
7. I am confident that I could exercise even without the support of my family or friends.
8. I am confident that I could exercise without the help of an exercise therapist.
9. I am confident that I can motivate myself to start being physically active or exercising again after I’ve stopped for a while.
10. I am confident that I could exercise even if I had no access to a gym or training facility.
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