DEVELOPING A HEALTH NUMERACY SCALE TO ASSESS MEDICAL DECISION MAKING AMONG OLDER ADULTS

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ABSTRACT

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Physical and cognitive decline in late adulthood is considered a normative change of aging. Consequently, the ability to make sound decisions regarding medical matters becomes an important factor in older adults’ well-being. As health information is often presented numerically, the ability to work with such information (health numeracy) is extremely important for making medical decisions (e.g., choosing a Medicare plan). While general numeracy has gained attention from aging and decision making researchers, the construct of health numeracy and its relationships with general numeracy and medical decision making were rarely studied. In study one, a measurement of health numeracy was developed and validated through an online sample (N = 262). Then the scale was refined through a Rasch analysis. In study two, the newly developed Health Numeracy Scale was cross validated in a community sample (N = 108). Regression analyses indicated that health numeracy was a more suitable predictor over general numeracy in predicting medical decision making in older adults. Implications and future directions of the findings were discussed.
I dedicate my dissertation to my daughter, Rae, whose diaper bills constantly reminded me that graduate student is not a real job.
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CHAPTER I: INTRODUCTION

As information is often presented numerically today, the ability to work with numbers (i.e., numeracy) becomes an essential skill in modern societies. Consequently, inability to understand and use numerical information can hinder one’s functioning in the society (Kirsch, Jungeblut, Jenkins, & Kolstad, 1993; Reder & Bynner, 2009). For instance, many high-paying occupations require extensive mathematical abilities. Without an adequate level of numeracy, one would be limited from many occupational possibilities. The effects of low numeracy go beyond employment. Peters, Västfjäll, Slovic, Mertz, Mazzocco, and Dickert (2006) reported significant positive correlations between numeracy and decision making competence. Specifically, in decision tasks where critical information is presented numerically, individuals with higher levels of numeracy outperformed their peers in choosing the best options and avoiding mistakes.

This positive relationship between numeracy and decision making has attracted attention from many medical decision making researchers. As critical health information is often numerical, decision makers need a basic level of numeracy to make sound decisions. Inability to make good medical decisions could lead to severe consequences to one’s physical and mental well-being. Unsurprisingly, studies have consistently found that individuals with lower levels of numeracy were more likely to make poor medical decisions and have poor health (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011).

Since older adults experience physical and cognitive decline in late adulthood, they are more likely to face decision tasks regarding medical matters in comparison to people from any other age groups. As health issues become more prevalent toward the later stages of life, inadequate numeracy can be especially problematic among older adults. Unfortunately, older
adults were consistently found to be less numerate than younger adults (e.g., Chen, Wang, Kirk, Pethtel, & Kiefner, 2014; Wang, Chen, & Fu, 2015). As numeracy is a critical factor in medical decision making, many studies found older adults to be less capable of making decisions in health-related contexts than younger adults. This was recognized as a major issue concerning the older adult population, and decision making research has been putting more emphasis on how numeracy changes in late adulthood. Despite its increasing popularity, this is still an emerging field of research.

A major shortcoming of research on numeracy is the limited number of assessment options. Currently, only a few scales are available for measuring numeracy, and even fewer were designed to use in the older adult population. In specific, the majority of the existing numeracy scales focus on general numeracy (e.g., computation, mathematical reasoning), and may be unsuitable for effectively assessing the ability to work with health-related numerical information (i.e., health numeracy) among older adults. Considering the limitations in the existing body of literature, I was motivated to develop a scale for measuring health numeracy among older adults. In addition, I also investigated the new health numeracy scale’s ability to predict medical decision making in comparison to other types of numeracy scales. Lastly, I explored the relationships among age, health numeracy and medical decision making competence among older adults.

Numeracy

The concept of numeracy is not novel in social science. In general, researchers agree that numeracy should incorporate a set of essential skills people need in order to work with numbers (e.g., Brown et al, 2011; Donelle, Hoffman, & Arocha, 2007; Reyna & Brainerd, 2007; Reyna, Nelson, & Han, 2009; Wright, Whitwell, Takeichi, Hankins, & Marteau, 2009). However, a
precise definition of numeracy is still under debate. Specifically, depending on the discipline, and its focus on numeracy, researchers have proposed different approaches in operationalizing this construct.

As mathematics is an essential component of modern education, the concept of numeracy has been a popular topic among education researchers. Educators usually refer to numeracy as a part of quantitative literacy (Wilkins, 2010). Similar to numeracy, a precise definition of quantitative literacy has not been established (Wilkins, 2010). Most educators agree that quantitative literacy should include the basic mathematics skills people need to function in modern societies (Steen, 1997a/1997b; Wilkins, 2000/2010). For example, simple skills such as counting, understanding numerical information including risk/benefit ratios, and computing simple operations from addition to division are all considered essential for someone to be quantitatively literate. However, where to draw the line between being quantitatively literate and quantitatively illiterate is still under debate.

Many educators have proposed that quantitative literacy goes beyond basic content knowledge in mathematics (e.g., Donn & Taylor, 1992; Gal, 1997; Mitman, Mergendoller, Marchman, & Packers, 1987; Wilkins, 2000/2010). For instance, Gal (1997) suggested that quantitative literacy should be “an aggregation of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem-solving skills” (p. 39). Similarly, Wilkins (2010) stated that a quantitatively literate individual should be willing to incorporate mathematics into his/her daily living. Specifically, in comparison to an individual who is not quantitatively literate, a quantitatively literate person should be more likely to reason mathematically, appreciate mathematics, and rely more on numerical information in daily living.
Since educators’ primary goal is finding ways to increase learning effectiveness, it is expected that their definitions of numeracy involve subjective evaluations of one’s skills and attitudes toward mathematics. While this abstraction of numeracy can be rooted to Bandura’s (1977, 1994) theory of self-efficacy, it is not something that can be objectively measured. In decision making research, where numeracy needs to be measured as a concrete construct, researchers have operationalized numeracy as the concrete ability to understand, analyze and act upon numerical information. Based on the existing instruments created for measuring numeracy, a common theme is to measure the ability to solve mathematical problems including simple computation, conversion, probability and mathematical reasoning (e.g., Weller, Dieckmann, Tusler, Mertz, Burns, & Peters, 2012).

**Numeracy and Decision Making**

As many decision making tasks often involve a large amount of quantitative information (e.g., odds ratios, graphical representations, etc.), the ability to work with such information could critically impact one’s ability to make sound decisions. Based on the existing pool of studies, people who are less numerate are often found to be less capable at decision making tasks involving numerical information (Peters, 2012; Reyna & Brainerd, 2007; Reyna & Brainerd, 2008; Reyna, Nelson, Han, & Dieckmann, 2009; Rothman, Montori, Cherrington, & Pignone, 2008; Schwartz, Woloshin, Black, & Welch, 1997; Wright, Whitwell, Takeichi, Hankins, & Marteau, 2009). In decision tasks that are simple and rudimentary, a lack of numeracy would not be problematic. However, many decision tasks we face are quite complex and inadequate numeracy skills could prevent one from making correct decisions. This is especially true when making decisions regarding health-related issues, in which critical information is often presented numerically.
Researchers have reached a consensus that numeracy plays an important role in medical decision making. Brown et al. (2010)’s findings supported this. In their study, the subjects were asked to research the details on different hypothetical breast cancer treatment plans, and then pick the most optimal treatment option. It was found that the individuals who had lower numeracy levels made more errors interpreting graphs concerning the outcomes of the treatment plans. And in turn, they made worse choices at choosing the best hypothetical treatment plans. The authors suggested that this effect of numeracy on decision making outcome could be explained through information processing. Since numeracy was required to understand the task relevant information, those with lower numeracy skills had more difficulties in correctly understanding the information conveyed in the graphs.

In another study, Rothman et al. (2006) investigated the relationship between numeracy and reading food labels. Consistent with Brown et al. (2010)’s finding, less numerate individuals made more mistakes at reading food labels. Specifically, a strong positive correlation was found between numeracy and comprehension of information from food labels. In both studies, evidence was found suggesting the effects of numeracy on decision making are through information processing. That is, those with an inadequate level of numeracy had more difficulties comprehending the numerical information, which, in turn, led to poorer decision making outcomes.

Peters (2012) investigated the effects of numeracy on a broader range of decision making tasks, and proposed that the effects of numeracy may go beyond simple comprehension of numerical information. In her investigations, a number of decision making studies involving numeracy were reviewed. For example, in Peters, Hess, Västfjäll, and Auman (2007)’s study, numeracy influenced the likelihood of the framing effect. Less numerate individuals were more
likely to be influenced by how numerical information was presented (i.e., positive frame VS. negative frame). In another study, Dieckmann, Slovic, and Peters (2009) found high numeracy could protect one from being distracted by irrelevant non-numerical information. The highly numerate individuals were able to gather critical information more effectively, whereas the less numerate subjects focused more on irrelevant information (e.g., whether the presenter of the information was attractive or not). A third study found that numerate decision makers were less likely to be biased by their own emotions (Västfjäll, Peters, & Starmer, 2011).

In addition to the positive relationship between numeracy and decision making competence, many studies have found that the effect of numeracy goes above and beyond that of general intelligence (e.g., Brooks & Pui, 2010; Låg, Bauger, Lindberg, & Friiborg, 2014; Peters, Västfjäll, Slovic, Mertz, Mazzocco, & Dickert, 2006). With general intelligence controlled, numeracy still contributed significantly to predicting decision making qualities. Therefore, it was agreed that numeracy should be treated as an independent construct in decision making research.

**Aging, Medical Decision Making and Numeracy**

With the rapid development of medical technology, an increase in lifespan has been observed across all developed nations. As the post-World War II population expansion generation (i.e., the baby boomer generation) moves into later adulthood, a rapid increase in the older adult population is observed in many countries. With the older adult population expanding, older adults’ well-being has been gaining more attention from decision making researchers in the past two decades.

During later adulthood when physical health deteriorates rapidly, older adults are at higher risks of suffering from physical and/or mental illnesses. As a result, whether older adults
can effectively choose the best options in health-related contexts would be critical to their physical health outcome and well-being. As mentioned above, numeracy plays a key role in understanding health-related information that is often numerically presented (e.g., tables and graphs). Unfortunately, studies have consistently found that older adults are generally less capable of working with numbers than younger adults (e.g., Castel, 2007; Chen, Wang, Kirk, Pethtel, & Kiefner, 2014; de Bruin, McNair, Taylor, Summers, & Strough, 2014; Schaie, 1996; Wang, Chen, & Fu, 2015).

The effects of lower numeracy skills were evident in studies that investigated decision making competence among older adults. For example, in a study on decision making performance of a Medicare Part D task, Wood and her colleagues (2011) found that older adults performed significantly worse than younger adults in picking out the most beneficial prescription options. In the Medicare Part D task, the participants were presented with a table consisting multiple options of pharmacies. The participants then had to choose the best options based on the instructions (e.g., choosing the cheapest one that offers mail order). While the younger adults consistently chose the best options, the older adults’ decisions were significantly less accurate. This difference in decision making competence was accompanied with age differences in numeracy skills.

Chen, et al. (2014) found similar results. In their study, younger and older adults were engaged in a financial decision making task (i.e., the cups task). In the cups task, the participants played a number of decision rounds to maximize gains and minimize losses. In each round, the participant had to choose between a safe option (100% chance to win $1) and a risky option (20%, 33% or 50% to win $2, $3, or $5). It was found that the older adults scored significantly lower in numeracy, and exhibited significantly lower levels of sensitivities to the differences in
Expected Values (i.e., expected outcome) between the decision options. The young participants consistently chose the risky option if it was more advantageous over the safe option (e.g., 50% chance to win $5), and avoided the risky options that were less advantageous (e.g., 20% chance to win $2). In contrast, older adults were less likely to take risks, especially when it was advantageous to do so in the gain domain. Furthermore, Chen et al. (2014) found that the negative relationship between age and Expected Value sensitivity was partially mediated by numeracy. That is, inadequate numeracy may have prevented older adults from effectively calculating the expected values.

Despite having an abundance of evidence on inadequate numeracy among older adults, few researchers investigated why this age difference exists. Within the limited literature on this issue, de Bruin et al. (2014) studied the role of motivation in numeracy, and found that the age difference in numeracy might be explained by a decrease in motivation in older adults. According to de Bruin et al. (2013), older adults may be less motivated to deal with mathematics, which consequently led to worse performances in numeracy tasks than younger adults. However, as motivation and performance often share an interactive relationship, this causal explanation may be flawed. While poor motivation could lead to poor performance, the same can be deduced in the opposite direction. In other words, the direction of causality is questionable in de Bruin et al. (2014)’s explanation.

In comparison to motivation, the working memory may be a better predictor of numeracy. Studies focusing on children and adolescents indicated that working memory is a significant predictor of mathematics acquisition and performance (Ashcraft & Krause, 2007). For instance, Holmes and Adamas (2006) found that the three components of working memory (i.e., visuospatial sketchpad, phonological loop, and central executives) all predicted unique variances
of mathematics performance. In addition, Bull and Scerif (2001) found that the top predictors of poor mathematics performance include inability to inhibit irrelevant information and retain/recall relevant information. Wang, Chen, and Fu (2015) investigated the role of working memory decline in the age differences in numeracy. Through bootstrapping analysis, it was found that working memory fully mediated the negative relationship between age and numeracy. Wang, Chen, and Fu (2015)’s finding suggested that the low numeracy observed in older adults could be associated with neurological decline in working memory during old age.

In addition to cognitive changes such as working memory decline, some researchers suggested that life experiences working with numbers could impact numeracy during later age. Castel (2007) studied age differences in the ability to memorizing numerical information. On average, younger participants outperformed older participants in all test conditions of a memorization-recall test. However, a small group of retired accountants and bookkeepers did significantly better than the younger group. Based on this finding, it was suggested that the amount of experience working with numbers could serve as a protector against age-related decline in numeracy.

The effects of working memory and experience in decision making tasks have been explained through the dual information processing model (Peters, Hess, Västfjäll, & Auman, 2007). In the dual information processing model, two distinct ways of information processing were proposed. The first is deliberative information processing. When engaged in this type of information processing, people carefully seek out and evaluate all relevant information before making decisions. The second is automatic information processing. This information processing style involves making quick decisions based on the emotions generated from the information. Specifically, if prior experiences are available concerning the decision information, people using
the automatic information processing could quickly make judgements on whether the information is positive or negative. As described in the model, people can freely switch between the two information processing styles, depending on the decision needs. For example, trivial decisions such as what to order at a restaurant often require automatic information processing; whereas important decisions such as which house to purchase are usually done through deliberative information processing.

While both types are useful in different contexts, age differences were found on the two information processing types between younger and older adults. It was found that younger adults could freely switch between the two information processing types based on needs; older adults were more likely to rely on automatic information processing when making decisions. Peters et al. (2007) explained this through age-related decline in working memory. In deliberative information processing, a large amount of information will need to be processed, which is demanding on one’s working memory. With more limited working memory capacities, older adults may rely on their past experiences and emotions to estimate the nature of the decision choices. In other words, this may be a protective mechanism older adults adopt to attempt to maintain independence. In everyday tasks where crucial consequence and long term effects are usually not involved, this would not pose any problem. However, in complex decisions such as retirement planning or choosing insurance policies, relying on automatic information processing could become a major problem.

Measuring Numeracy

Because of the significant role of numeracy in older adults’ well-being, it is important to gain more understanding about numeracy during later adulthood. To do this, an effective way to
measure numeracy is required. Depending on the circumstances and the population of interest, there are several different instruments for measuring numeracy.

As mentioned, numeracy has been a popular topic of interest for educators. In modern societies, mathematic abilities are extensively assessed many times in one’s education. The most common method of assessing mathematics abilities used by educators is standardized testing (Kohn, 2000). In most commonly used standardized tests in the American education system (e.g. SAT, ACT), there is at least one section dedicated to measuring mathematics performance. As a massive amount of effort is put into the development of standardized tests, they could measure one’s comprehensive mathematical ability. However, the limitations of such tests are also apparent. Standardized tests are expensive to administer, and can take a long time to complete. As a result, standardized mathematical tests are seldom used outside of the education field. It would be unrealistic to use such tools in everyday assessments of numeracy, especially among the older adult population.

Researchers in social sciences have designed numeracy scales that are shorter and easier to administer. Early objective numeracy scales designed by social scientists focused primarily on the ability to calculate probabilities (e.g., Schwartz et al., 1997). In their numeracy scale, Schwartz et al. included three items measuring basic probability calculations (e.g., how many times a fair, six-sided die would come up even out of one thousand rolls). Lipkus, Samsa, and Rimer (2001) added a 7-item numeracy scale that assessed people’s ability to understand and convert between percentages, proportions and probabilities to the numeracy scale designed by Schwartz et al. (1997). Items used in this numeracy scale were mostly simple calculation and conversion problems (e.g., if Person A’s risk of getting a disease is 1% in ten years, and person B’s risk is double that of A’s, what is B’s risk?). Peters et al. (2005) criticized this numeracy
scale’s difficulty range. In their study, the scores derived from this numeracy scale were heavily skewed toward the maximum range. In other words, the difficulty level of this scale may be too low to accurately assess individual differences in numeracy skills.

Cokely, Galesic, Schulz, Ghazal and Garcia-Retamero (2012) developed a 4-item numeracy scale (the Berlin numeracy scale). Similar to the previous numeracy scales, the Berlin numeracy scale also targeted people’s abilities to calculate probabilities. However, the complexity of the Berlin numeracy scale is comparably more advanced than Lipkus et al. (2001)’s scale. Consequently, solving problems from this scale would require a much deeper understanding of probability. For example, one of the items tests knowledge of conditional probability (e.g., out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?). It was not surprising that Cokely et al. (2012) stated that the Berlin numeracy is only suitable for those with advanced education. In a pilot study, Wang, Chen, and Fu (2015) found 45% of the participants failed to answer any of the items on the Berlin numeracy scale correctly. Considering this limitation, the Berlin numeracy scale is likely to be unsuitable for the older adult population.

Weller, Dieckmann, Tusler, Mertz, Burns, and Peters (2012) took consideration of the issue of difficulty levels in creating a new numeracy scale. Eighteen items from existing numeracy scales were tested, and 8 were kept in the final version. In comparison to the previous numeracy scales, Weller and colleagues (2012)’s scale had a wider range of difficulties, thus making itself more suitable for a more diverse population. Items on this scale ranged from basic ratio-percent conversion to more complex problems involving conditional probability. Despite
this vast improvement over previous numeracy scales, the items on Weller and colleagues (2012)’s scale were not constructed specifically for a health-related context. For instance, one of the items from this numeracy scale tested for people’s mathematics knowledge of exponential growth (e.g., In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?). This item was designed to test the ability to solve problems involving exponential growth. However, such ability is not directly relevant to medical decision making or older adults’ life experiences dealing with health-related issues. While this scale was designed to be effective in testing basic mathematical skills, its content validity in measuring health numeracy was not established. Interestingly, anecdotal interviews from a previous study using this scale (Wang, Chen, & Fu, 2015) found that many older adults expressed dismay at these abstract problems and found them disorienting.

It is worth mentioning that a unique numeracy scale was developed by Fagerlin et al. (2007). While the other numeracy scales were all objective measures of general numeracy, Fagerlin et al. (2007)’s scale was designed to measure numeracy subjectively. Specifically, in this scale, eight items were included asking respondents to self-evaluate their abilities and attitudes toward numbers and mathematics (e.g., When you hear a weather forecast, do you prefer predictions using percentages or predictions using only words? (1 = always prefer percentages, 6 = always prefer words)). The Subjective Numeracy Scale was tested in comparison to other numeracy scales, and was found to be highly related to objective numeracy. In addition, respondents taking the Subjective Numeracy Scale reported being less stressed. However, despite its established convergent validity with other objective measures of numeracy, evidence is still lacking on whether it is useful in predicting medical decision making.
Health Numeracy

Health numeracy refers to the set of skills to work with numerical information in health-related situations. It is defined as “the degree to which individuals have the capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions” (Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005, p. 375).

Golbeck et al. (2005) proposed that health numeracy should be operationalized into four categories: Basic, Computational, Analytical, and Statistical. Basic health numeracy refers to the skills to understand the basic sense of numbers. Based on the authors’ explanation, a person who possesses basic health numeracy should be able to complete basic tasks (e.g., taking the correct number of pills) that are related to health. The second category, computational health numeracy, involves skills to manipulate numbers. Specifically, counting and mathematical operations are essential skills within this category. Relating to health, the ability to calculate how much medicine to take based on variables such as age, body weight, degree of symptoms is categorized under computational health numeracy. Analytical health numeracy describes the set of skills that enable one to comprehend numerical information and make inference and estimates. Without mastering this category of health numeracy, people can be ineffective in making decisions regarding health-related issues. The last category in Golbeck et al. (2005)’s model is statistical health numeracy. As the name suggests, this type of health numeracy involves the understanding of statistics and probability. Skills incorporated into statistical health numeracy range from a basic sense of probability to more advanced knowledge of statistics (e.g., understanding what statistical significance stands for). Golbeck et al. (2005) suggested that the four categories of health numeracy are overlapping clusters of concepts and abilities that together define health
numeracy. In other words, the four categories should not be treated as mutually exclusive. Instead, skills from each of the categories could contribute to those from another category.

*The Present Studies*

While there are many numeracy scales available, few were designed to measure health numeracy. Although it was found that general numeracy could predict medical decision making in older adults (e.g., Wood et al., 2001), a numeracy scale that is designed to specifically measure health numeracy may have higher predictive validity. Considering the limitations of the literature on aging, health numeracy, and medical decision making, the present studies aimed to develop a health numeracy scale to effectively measure health numeracy among older adults. In particular, this study investigated the convergent validity of the health numeracy scale with other general numeracy scales and the predictive power of the newly developed health numeracy scale on medical decision making. Based on the existing literature on numeracy, and the characteristics of older adults, this study focused on the following objectives in the development of the new scale.

The first objective was to develop an effective tool for measuring health numeracy. For content validity, the items in the scale need to be about health-related issues. A task-relevant numeracy scale may generate more accurate results in measuring people’s ability to work with health-related numerical information. Furthermore, health numeracy may be more relevant to older adults’ real life experiences. Based on evidence provided by previous studies (e.g., Gazzaley, Cooney, Rissman, & D’Esposito, 2005), using task-relevant numeracy items could potentially reduce the stress on older adults’ working memory. For convergent and predictive validities, the results of the health numeracy scale were compared to other established measurements of numeracy as well as predicting the quality of medical decision making.
Specifically, as operationalized by decision making researchers (e.g., Golbeck, 2005), health numeracy is a subset of numeracy skills that specifically deals with health-related numerical information, and therefore should be correlated with general numeracy. By comparing to existing measures of numeracy, the convergent validity of the health numeracy scale can be tested. In addition, as the link between general numeracy and medical decision making has already been established, a health numeracy scale should be able to predict medical decision making performance as well.

In addition to having satisfying validities, the scale needs to be precise and have an acceptable range of difficulty levels. This way, the scale can effectively measure health numeracy in older adults without generating confounding problems (e.g., math anxiety, floor or ceiling effect). Math anxiety is the anxiety people often experience when performing mathematics tasks (Ashcraft & Kirk, 2001). The effects of math anxiety on mathematical performance have received substantial attention from educators and psychologists. Evidence suggests that when math anxiety is present, the negative effect of poor working memory on performance is especially significant (e.g., Beilock & Carr, 2005). It was found that math anxiety is likely to arise during complex mathematics tasks (Ashcraft & Faust, 1994; Faust, Ashcraft, & Fleck, 1996). Taking this into consideration, a long and complex numeracy scale might be viewed as daunting by many. This is especially problematic among the older population. As working memory declines in old age, a long and complex numeracy scale might not only seem threatening, but also put unnecessary burden on older adults’ working memory. Therefore, necessary procedures should be taken to refine the health numeracy scale. Study 1 used Rasch analysis in determining the appropriateness of the health numeracy items similar to what Weller et al. (2012) did in the development of their abbreviated numeracy scale.
Today, internal consistency-based analysis has been widely used in scale development (Clark & Watson, 1995). Specifically, when using this method, items that have lower correlations with the assessed construct would be dropped to increase the measurements’ internal consistency. However, this method has been criticized for its evidence-driven nature by psychometricians (e.g., Smith, McCarthy, & Anderson, 2000; Weller et al., 2013). Specifically, according to Smith, McCarthy, and Anderson (2000), eliminating items based on internal consistency could potentially eliminate other important information as well (e.g., constructive validity, etc.). As one of this study’s primary goals was to design a measurement of health numeracy with reasonable ranges of difficulty levels, an Item Response Theory (IRT)-based scaling method designed by Rasch (1993) was used. The Rasch analysis takes into consideration the test takers’ abilities in a construct and the difficulty levels of the items, and generates a difficulty parameter for all of the items. Specifically, in the Rasch model, the difficulty parameter represents the level of ability a person needs to answer an item correct with a probability of 50%. This item reduction method has been used in circumstances such as placement test development, where the test difficulty level needs to be controlled.

In Study 1, a prototype health numeracy scale was constructed for older adults. Specifically, sixteen numeracy items with health-related contexts were created according to Golbeck et al. (2005)’s model of health numeracy. Four items covering various difficulty levels were created for each of the four health numeracy dimensions (i.e., basic, computational, analytical, and statistical). After the prototype items were made, they were evaluated by professional peers on face validity and difficulty level. Modifications were made based on the received feedback. Then the items were distributed to seventy-seven undergraduate students for
preliminary pilot testing. Further modifications were made based on consistent errors in the pilot data.

As the present study’s goal was to create a health numeracy scale for older adults, only those who were between 45 to 75 years of age were recruited. Study 1 developed the health numeracy scale and used the Rasch analysis to refine the health numeracy scale. Convergent validity with another general numeracy scale and their effectiveness in predicting medical decision making were also tested. Study 2 cross validated the newly developed Health Numeracy Scale in another sample and investigated the relationships between age, health numeracy, and medical decision making.
CHAPTER II PART A: STUDY 1 METHODS

Participants

In the first study, the new health numeracy scale was tested with an online sample to determine its convergent validity and predictive validity. Three hundred participants between the age of 45 and 75 were recruited via Amazon Mechanical Turk (Mturk). Thirty-eight were excluded from the analyses due to missing or unusable data (e.g., responded to all items with obviously false answers). To ensure adequate age distribution, a roughly equal number of participants were recruited in three age ranges (i.e., 45-55, 55-65, and 65-75). In addition, restriction on IP addresses was put into effect such that only IP addresses in the United States could gain access to the study. The mean age was 58.24 (SD = 8.33). Ninety-two percent of the participants were native English speakers, 55.7% were male and 59% were Caucasians. The sample consisted of 28.6% Asians, which was higher than the racial demographics of the U.S. However, this was expected with data collection via Mturk (Ipeirotis, 2010). In addition, 8.8% of the sample reported suffering from some form of chronic disease, but none reported suffering from cognitive impairment such as dementia. Table 1 shows the detailed summary of the demographic information of the sample. Lastly, all of the participants received $1 as reward for participation.

Design and Procedure

Study 1 was conducted online. The measurements were uploaded to Qualtrics. Three versions that were identical with the exception of the age requirement were created for the three age ranges. The generated links were then posted onto Mturk. The participants were given an automatically generated code after completing the questionnaires, and had to enter the code in
Mturk to receive $1. Age restrictions were created such that only those who were within the age ranges were given access to the measurements. All respondents had to enter their birth year on the consent form. Those who entered birth years outside of the required range were directed to the final page of the survey, and were not given a code for incentive. In addition, each IP address could only access the survey once. This was implemented to avoid multiple attempts of the survey by individuals with multiple accounts. After giving consent, the eligible participants were given a background questionnaire, followed by the health numeracy scales, the Abbreviated Numeracy Scale (Weller et al., 2012), the Subjective Numeracy Scale (Fagerlin et al., 2007), and finally a medical decision making task (Woods et al., 2011). The average time for completing the survey was roughly 25 minutes. The participants were asked not to use a calculator for the numeracy items. Two dummy items were put into the survey to check whether the participants were paying attention. Two final questions asking whether they had used a calculator, or had inputted anything randomly were at the end of the survey.

Measurements

Background Questionnaire. Demographic characteristics (i.e., age, gender, ethnicity, education level, occupation, income and health) were collected through a background questionnaire. In addition, an item asking whether participants had suffered from physical and/or chronic conditions was added for screening purposes (See Appendix A).

Health Numeracy Scale Item Pool: A total of sixteen health numeracy items were created. The items were based on Golbeck et al. (2005)’s model of health numeracy (i.e., basic, computational, analytical, and statistical). For each of the subsets, there were four items ranging from easy to difficult. All of the items were evaluated by a group (N = 4) of social science researchers to ensure acceptable face validity and difficulty level. Based on the feedback,
necessary revisions were made. Then the items were tested in a pilot study with undergraduate students at a university in Ohio (N = 77). Based on the result, minor editions were done to correct some of the problematic wordings (See Appendix B).

**Abbreviated Numeracy Scale.** To assess the convergent validity of the health numeracy scale, a general numeracy scale was included in this study. General numeracy was measured through the abbreviated numeracy scale (see Appendix C) designed by Weller, Dieckmann, Tusler, Mertz, Burns, and Peters (2012). The abbreviated numeracy scale is based on the numeracy measurements designed by previous researchers (e.g. Frederick, 2005; Lipkus et al., 2001; Peters, Hibbard et al., 2007; Schwartz et al., 1997). Through the Rasch analysis (Rasch, 1960/1993), eight final items were included in the abbreviated numeracy scale. The abbreviated numeracy scale was designed to have a wider range of difficulties in comparison to previous instruments, thus making itself more suitable for a broader population. Specifically, items on this scale ranged from simple conversion between ratios and percentages to more complex problems involving conditional probability. The final score is the total number of correct responses. The Abbreviated Numeracy Scale was internally consistent (α = .76).

**Subjective Numeracy Scale:** In addition to the abbreviated numeracy scale, Fagerlin et al. (2007)’s self-reported scale of subjective numeracy was also included for validation purposes. The Subjective Numeracy Scale is a measurement of mathematical self-efficacy. The Subjective Numeracy Scale consisted of 8 Likert scale questions asking various attitudes toward mathematics and numbers (e.g., How good are you at calculating a 15% tip? 1: not good at all; 6: extremely good). This scale was developed to measure people’s subjective evaluations of their numeracy skills, and was found to be highly correlated with results from objective numeracy scales. In addition, Fagerlin et al. (2007) reported more positive feedback with the Subjective
Numeracy Scale over regular scales (See Appendix D). Lastly, Fagerlin et al. (2007) reported the Subjective Numeracy Scale to be internally consistent ($\alpha = .82$).

**Medical Decision Making Task:** The Medicare Part D decision-task designed by Woods et al. (2011) was used for measuring decision making performance. In this decision-task, a list of 10 insurance choices were presented to participants. Each choice had several criteria attached (e.g., cost, deductible, number of pharmacies available, etc.). Participants were asked to choose the most suitable plans based on specific needs (See Appendix E).
CHAPTER II PART B: STUDY 1 RESULTS

*Health Numeracy Score*

The 16 health numeracy items were graded such that each correct response received a score of 1, and incorrect response received 0. A detailed summary of the descriptive statistics of the individual items can be found in Table 2. The Cronbach’s $\alpha$ of all 16 items was .72.

*Exploratory Factor Analysis*

The Rasch analysis assumed that the assessed construct is a unidimensional construct (Rasch, 1960/1993). In order to assess the dimensionality of the health numeracy construct measured by the health numeracy items, an exploratory factor analysis (EFA) was conducted. Results indicated that four factors emerged. However, the factoring did not occur in a meaningful fashion. That is, the factoring of the items did not follow the model described by Golbeck et al. (2005), and appeared to be randomly grouped. In addition, since factor 1 explained 28.34% of the total variance (Eigenvalue = 2.84), the condition for unidimensionality of the health numeracy construct was reasonably satisfied for the Rasch model to be used.

*Rasch Analysis*

To assess the difficulty parameters of the items, a Rasch analysis was used on all items using IRTPRO software. Based on the existing literature, a difficulty parameter range of (-1.6, 1.6) was deemed acceptable for the purpose of the health numeracy scale. Items 1, 2, 3, 4, 7, 9, 10, 11 and 14 were dropped for having a difficulty level that was too easy. Item 15 was dropped for being too difficult. The remaining items after the Rasch analysis were: Items 5, 6, 8, 12, 13 and 16. See Table 2 for the difficulty parameters of the individual items.
Validities

The scores of the 16 health numeracy items were added together to form a total score (mean = 12.09, SD = 2.63). Another variable consisting of the sum of the remaining items (5, 6, 8, 12, 13 and 16) was calculated separately. A Pearson’s correlation analysis showed that the total score of health numeracy significantly correlated with general numeracy (r = .567, p < 0.001) and with subjective numeracy (r = .158, p < 0.01). Table 3 shows the correlation matrix of the variables. In addition, as expected, general numeracy significantly predicted medical decision making (F (1, 260) = 58.21, p < 0.001). The total score of health numeracy also significantly predicted medical decision making (F (1, 260) = 99.9, p < 0.001), and had a higher effect size (R² = .296) than general numeracy (R² = .183). A multiple regression analysis showed that the R² values were significant different between a model where general numeracy was the only predictor of medical decision making (R² = .183) and a model where both general numeracy and health numeracy were included as predictors (R² = .303) (F (1, 259) = 44.50, p < 0.001). In other words, the incremental validity of the health numeracy items were found to be satisfactory. However, subjective numeracy did not predict medical decision making (F (1,260) = 1.75, p = .19). More importantly, the score from the refined health numeracy items showed stronger predictive validity than the total score. Specifically, the refined score has the highest predictive power of the medical decision making outcome (F (1,260) = 117.69, p < 0.001, R² = .312). See Table 4 for the regression statistics.

Aging, Health Numeracy and Medical Decision Making

Through a Pearson’s correlation analysis, weak positive correlations were found between age and the health numeracy scores (R_{total} = .127, p < 0.05; R_{refined} = .144, p < 0.05). However, age did not correlate with other variables. Therefore, no further analyses were performed.
CHAPTER II PART C: STUDY 1 DISCUSSION

In Study 1, the pool of health numeracy items were tested through an online sample. Both convergent validity and predictive validity of the health numeracy scale were satisfied. More importantly, by using a Rasch analysis, the number of items was successfully reduced to meet a more reasonable length and difficulty range.

The results of study 1 were mostly satisfactory. Specifically, the refined health numeracy scale was shorter and had a higher effect size in predicting medical decision making than both the general numeracy scales. Also, as the Medicare Part D decision task by Wood et al. (2011) was representative of real life medical decision making older adults might face, the results of this study provided evidence suggesting that the health numeracy scale may be a more suitable predictor of medical decision making in older adults than the general numeracy scales.

Unlike previous studies, this study did not find age as a predictor of general numeracy or medical decision making. A potential explanation is that since the sample was an online sample from an online marketplace for work, the participants may be relatively high-functioning older adults. In addition, whereas most of the studies investigating age differences in numeracy and/or decision making compared older adults with younger adults, this study primarily focused on older adults (i.e., 45 – 75). Interestingly, age appeared to have a weak positive relationship with health numeracy. This could potentially suggest that the health numeracy scale was more task-relevant to older adults’ daily experiences, and thus was improved with age. Specifically, due to more limited working memory capacity, older adults were found to be worse at tasks where they could not rely on their experiences. Since health numeracy measures the ability to work with health-related information, its content may be more relevant to older adults’ experience dealing
with medical issues than general numeracy. Therefore, a slight age-related increase was
observed. However, more studies will be needed to draw solid conclusions.

Lastly, as Study 1 used an online sample to validate and refine the health numeracy
items, a second study was conducted with a community sample to cross validate the health
numeracy scale. Specifically, a second study tested the refined health numeracy scale’s
predicative validity in older adults who were community dwellers.
CHAPTER III PART A: STUDY 2 METHODS

**Participants**

The refined health numeracy scale was tested with a community sample. One hundred and twenty people participated in the study. All of them were community dwellers in the Midwest region of the U.S. Similar to the first study, the participants of the second study were equally divided among three age groups (i.e., 45-55, 55-65, and 65-75). Twelve participants were dropped from the study due to incomplete data. Participant recruitment was done through local advertisement and a snowball method. Information concerning the study was given to those who reported having acquaintances who might be interested. Nine participants were randomly chosen and awarded a $20 Amazon gift card.

The average age of the participants was 61.9 years (SD = 5.63). All of the participants were native English speakers. Forty-one percent were male and 90.7% were Caucasians. The gender and racial demographics were consistent with the general population of the region where data collection took place. The education level of this sample was higher than the national average, with 32.4% having bachelor’s degree and 29.6% advanced degrees. Most of the participants reported having good or excellent health (77.3%), and only 3.7% reported suffering from chronic disease. However, none of the participants reported suffering from cognitive impairments. A detailed report of the demographic information can be found in Table 5.

**Design and Procedure**

Depending on the participants’ personal needs, both paper and online versions of the survey were used for data collection. Those who were able to meet in person were given the paper version, and those who preferred responding to the survey in their own time were given a
link to the survey on Qualtrics. After giving consent, the participants were given the same background questionnaire from the first study, followed by the refined health numeracy scale, and finally the Medicare Part D task (Woods et al., 2011). Lastly, all participants were asked to leave their contact information for the random drawing of the gift cards. All of the participants were told not to use a calculator. Unlike in Study 1, in Study 2, no restrictions on IP addresses were made on the online version of the survey.

**Measurements**

*Background Questionnaire:* The same background questionnaire was used for study 2. In this questionnaire, standard information including age, gender, ethnic/racial background, education level, health status and history of chronic diseases were asked.

*Refined Health Numeracy Scale (rHNS):* Since the objective of the second study was to cross validate the health numeracy scale in a community sample, the refined version of the scale was used ($\alpha = .69$). The refined version kept items 5, 6, 8, 12, 13 and 16 based on the result of a Rasch analysis, and was found to have strong convergent validity and predictive validity. All other instructions were the same as those of Study 1.

*Medical Decision Task:* The same Medicare Part D task by Wood et al. (2011) was used. As mentioned before, this decision task was representative of real world medical decision making, and thus was considered an appropriate task to use in this study.
CHAPTER III PART B: STUDY 2 RESULTS

The score of rHNS was the sum of the 6 items (mean = 4.55, SD = 1.21). Simple linear regression analysis showed that it significantly predicted medical decision making ($F (1, 106) = 20.08, p < 0.001, R^2 = .16$). In addition, Pearson’s correlation analysis indicated that age did not correlate with health numeracy or medical decision making. Thus, no further testing was done investigating the relationships between age, health numeracy and medical decision making.
CHAPTER III PART C: STUDY 2 DISCUSSION

Study 2’s purpose was to cross validate rHNS’s validity in a community sample. The results indicated that the refined scale was useful in predicting medical decision making performances in older adults who are community dwellers.

Similar to the results from study 1, study 2 did not find any age effect on decision making. In addition, this study did not find a significant relationship between age and health numeracy. Again, this may be explained by the same reasons as those of Study 1. First, it may be due to the restricted age range. Only older adults were included in this study. Second, the relevant content of the health numeracy scale and the medical decision task may be familiar to older adults thus reducing the negative impact of working memory decline during older age.
CHAPTER IV: GENERAL DISCUSSION

While numeracy has been gaining attention from decision making researchers, few took consideration of health numeracy that deals exclusively with health-related numerical information. To my knowledge, this study was one of the first to create, validate and refine a tool for measuring health numeracy in older adults.

Specifically, 16 health numeracy items were created and tested with an online sample. Comparisons with a general numeracy scale (Weller et al., 2012) and the Subjective Numeracy Scale (Fagerlin et al., 2007) showed convergent validity. Regression analyses indicated that health numeracy may be a better variable in predicting medical decision making over general numeracy, thus satisfying the criteria for better predictive validity. More importantly, through a Rasch analysis, the pool of the original 16 health numeracy items was successfully refined to 6 items (rHNS). Correlation and regression analyses showed that rHNS maintained or even improved its convergent and predictive validity. In addition, by applying the Rasch model, the remaining items possessed a reasonable range of difficulty levels to use among older adults. Lastly, rHNS was cross validated with a community sample. Results showed that the scale did hold up its predictive validity moving from an online sample to a community sample. Therefore, it is reasonable to believe that rHNS is generalizable to the older adult population in the U.S.

Overall, the main goal of this study was successfully reached: to develop a short health numeracy scale to use in older adults.

*Health Numeracy Scale*

Numeracy has been repeatedly found to be a critical variable in medical decision making. Many have proposed that the ability to understand and work with numerical information is
essential to making medical decisions, in which a large amount of critical information is presented numerically. However, while general numeracy does predict the ability to deal with health-related numerical information, the health numeracy construct should be more beneficial to use in the older adult population. In other words, a health numeracy scale may hold better practical purposes in aging research or clinical settings involving older adults. Evidently, rHNS was shorter and out-performed the general numeracy scale in predicting medical decision making in older adults.

*Health Numeracy and Medical Decision Making*

This difference between rHNS and the general numeracy scale in predicting medical decision making may be explained by the age-related decline in attention and working memory in older adults. It is well known that as our physical capacity deteriorates, our cognitive abilities also decline (Shepherd, 1997). This normative change is especially noticeable in our fluid intelligence. With lower working memory and attention capacities, older adults were found to be more distractible by task-irrelevant information, more susceptible to framing effects, and more likely to be overwhelmed by a large amount of information (Peters et al., 2007).

In addition, older adults were found to be more likely to rely on their emotions to make decisions when they cannot relate the information with their experiences and knowledge (Peters et al., 2007). Taking consideration of the limitations in older adults’ cognitive abilities, the biases in their decision making processes, and their experiences in dealing with health-related issues, it is reasonable to conclude that a precise measurement of health numeracy would be more suitable on this population than a general numeracy scale. In comparison to the general numeracy, the health numeracy items are more familiar to older adults. Anecdotally, many older participants from our previous study (Wang et al, 2015) complained that the general numeracy items in
Weller et al. (2012)’s Abbreviate Numeracy Scale were strange and not relevant to their everyday use of numeracy. By using a task-relevant scale, older adults’ numeracy skills that are related to medical decision making may be measured more effectively. As shown in this study, rHNS outperformed its general counterpart in predicting the qualities of decisions regarding choosing Medicare Part D plans. Furthermore, as de Bruin et al. (2014) suggested, motivation is likely a key predictor of numeracy among older adults. A longer and general numeracy scale may be considered more negative by test takers, and therefore generate more math anxiety. By comparison, rHNS was shorter and health-related. Thus, this scale may be better at reducing test anxiety of older adults than the general numeracy scales.

Interestingly, subjective numeracy, or mathematical self-efficacy, did not predict medical decision making. Consistent with previous findings, subjective numeracy did correlate with general numeracy \( r = .265, p < 0.001 \). This suggested that while self-evaluation of numeracy skills could reflect actual numeracy skills to some degree, caution should be taken when using it to predict medical decision making.

Lastly, a second study using another sample indicated that the health numeracy scale could be generalized to community samples. However, when using it to predict medical decision making in the community sample, the effect size decreased (from \( R^2_{\text{Online}} = .31 \) to \( R^2_{\text{Community}} = .16 \)). While the sample size differences may contribute to this result, it is also likely that the higher-than-average education levels of the community sample biased the outcome of the study. A post-hoc two-sample t-test showed that the community sample (mean = 2.6, SD = 1.2) did significantly better than the online sample (mean = 2.18, SD = 1.3) at the Medicare Part D task \( (t(368) = 3.01, p < 0.05) \).
Age, Health Numeracy and Medical Decision Making

Interestingly, with the exception of weak positive correlations with rHNS in the online sample, age did not appear to have any significant relationship with other measured variables. At the first glance, this seems to contradict existing findings which suggest that age has a negative correlation with decision making competence. But, closer examination of the existing literature suggests that almost all of the age differences found were between younger and older adults (e.g., Chen et al., 2014). Since the goal of this study was to develop a health numeracy scale for older adults, only those who were between 45 years and 75 years old were included. Therefore, the results of this study were not contradictory to the previous studies that did find age differences in numeracy and decision making.

Implications and Contributions

As stated, due to physical and cognitive declines, decision making competence in old age could be very critical to one’s well-being. As a result, it is important to gain more understanding on how decision making changes in later adulthood. In addition, it is also helpful for professionals who work with older adults to effectively assess older adults’ ability to function independently. Since numeracy is a key predictor of medical decision making, an effective measurement of health numeracy would be needed in studying medical decision making in older adults. This study developed a relatively short health numeracy scale that demonstrated both convergent validity and predictive validity of medical decision making among older adults. Since health numeracy is a rarely studied construct, and considering its advantages over the general numeracy scale in predicting medical decision making, the scale developed in this study could potentially become a standard tool for assessing health numeracy among older adults.
Limitations and Future Directions

This study developed and cross validated a health numeracy scale that held better predictive power on medical decision making over general numeracy. However, there are limitations that should be addressed in future research.

First, as proposed by Golbeck et al. (2005), health numeracy may be a multidimensional construct. In other words, a single score may not be comprehensive enough to present one’s health numeracy level. A larger bank of health numeracy items would be needed to effectively investigate potential dimensions of health numeracy. Future research on health numeracy may expand the scale to explore potential dimensions in this construct.

Second, a majority of the participants in this study were high functioning middle-aged or older adults with relatively good health. Since the ultimate goal of developing a health numeracy scale is to use it in everyday and clinical settings, more tests will be needed to determine whether this scale could be used with older patients who have physical or cognitive disabilities.

Third, due to the higher than average education level from both samples in this study, the difficulty range of rHNS may need further investigation. Specifically, since rHNS’ difficulty range was based on highly educated high-functioning older adults, more studies may be needed to make necessary adjustments to the difficulty levels.

Fifth, as one of the advantage of health numeracy over general numeracy in predicting medical decision making may be its relevance to older adults’ existing experiences navigating through medical issues, it may be beneficial to explore the relationship between health numeracy and older adults’ literacy level. By doing so, more distinction could be made between the two constructs.
Lastly, even though this study used a medical decision making task that is representative of real life, medical decisions go beyond simply choosing pharmacies. Whether health numeracy can predict other types of medical decisions should be tested in future research.

Conclusion

To my knowledge, this study is the first to develop a tool for measuring health numeracy among older adults, and to investigate the relationship between health numeracy and medical decision making. The findings suggested that rHNS could be a more suitable tool to use in medical decision making research involving older adults. Furthermore, since this scale could effectively predict real world medical decision making, it may hold application potential in clinical settings for older adults. At least, it could serve as a stepping stone for future investigations of health numeracy and medical decision making.
REFERENCES


## APPENDIX A. TABLES

### Background Information for Study 1 (N = 262)

<table>
<thead>
<tr>
<th>Survey Items</th>
<th>Descriptive</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Min = 45 yrs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max = 75 yrs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean = 58.24 yrs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD = 8.33 yrs.</td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>Male: n = 146</td>
<td>55.7%</td>
</tr>
<tr>
<td></td>
<td>Female: n = 116</td>
<td>44.3%</td>
</tr>
<tr>
<td><strong>Native Language</strong></td>
<td>English: n = 240</td>
<td>91.6%</td>
</tr>
<tr>
<td></td>
<td>Other: n = 22</td>
<td>8.4%</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td>Single: n = 43</td>
<td>16.4%</td>
</tr>
<tr>
<td></td>
<td>Married: n = 163</td>
<td>62.2%</td>
</tr>
<tr>
<td></td>
<td>Divorced: n = 40</td>
<td>15.3%</td>
</tr>
<tr>
<td></td>
<td>Widowed: n = 16</td>
<td>6.1%</td>
</tr>
<tr>
<td><strong>Ethnic Background</strong></td>
<td>African American: n = 14</td>
<td>5.2%</td>
</tr>
<tr>
<td></td>
<td>Asian: n = 156</td>
<td>59.5%</td>
</tr>
<tr>
<td></td>
<td>Caucasian: n = 13</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Native American: n = 3</td>
<td>1.1%</td>
</tr>
<tr>
<td></td>
<td>Asian: n = 75</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Other: n = 1</td>
<td>.4%</td>
</tr>
<tr>
<td><strong>Highest Degree Received</strong></td>
<td>High School: n = 46</td>
<td>17.6%</td>
</tr>
<tr>
<td></td>
<td>Associate: n = 37</td>
<td>14.1%</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s: n = 108</td>
<td>41.2%</td>
</tr>
<tr>
<td></td>
<td>Advanced: n = 71</td>
<td>27.1%</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td>Below $20,000: n = 42</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>$20,000 - $40,000: n = 83</td>
<td>31.7%</td>
</tr>
<tr>
<td></td>
<td>$40,000 - $60,000: n = 68</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td>Above $60,000: n = 69</td>
<td>26.3%</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td>Poor: n = 7</td>
<td>2.7%</td>
</tr>
<tr>
<td></td>
<td>Fair: n = 75</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Good: n = 159</td>
<td>60.7%</td>
</tr>
<tr>
<td></td>
<td>Excellent: n = 21</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Chronic Disability</strong></td>
<td>No: n = 239</td>
<td>91.2%</td>
</tr>
<tr>
<td></td>
<td>Yes: n = 23</td>
<td>8.8%</td>
</tr>
</tbody>
</table>
## Table 2

### Percent Correct and Difficulty Parameter of the 16 Health Numeracy Items

<table>
<thead>
<tr>
<th>Items</th>
<th>Correct Rate</th>
<th>Difficulty Parameter (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Your doctor told you to take Tylenol if your temperature reaches 101 degrees. Your current reading is 100.5. Do you need to take Tylenol?</td>
<td>.93</td>
<td>-3.05</td>
</tr>
<tr>
<td>2. You are on a monthly prescribed medicine. You just filled it today. Roughly how many more days are there before you have to refill the medicine?</td>
<td>.92</td>
<td>-2.93</td>
</tr>
<tr>
<td>3. For diastolic blood pressure, less than 80 is normal, between 80 and 89 indicates prehypertension, 90 or above is considered to be hypertension. Joseph’s most recent blood pressure test reads 117/76. Does Joseph have hypertension?</td>
<td>.92</td>
<td>-2.93</td>
</tr>
<tr>
<td>4. Two sites are available for a treatment. Your insurance will cover 80% of expenses from site A and .85 of expenses from site B. Which site is more advantageous?</td>
<td>.95</td>
<td>-3.34</td>
</tr>
<tr>
<td>5. A prescribed medicine costs $50 to fill. Your insurance covers 90% of the total price. How much do you need to pay out of your own pocket?</td>
<td>.70</td>
<td>-1.04</td>
</tr>
<tr>
<td>6. Frank needs to take Bromocriptine for his Parkinson’s disease. The recommended dosage is 5 mg/day. Bromocriptine comes in 2.5 mg pills. How many pills should Frank take each week?</td>
<td>.66</td>
<td>-0.79</td>
</tr>
<tr>
<td>7. Maria needs to take a medication every 8 hours. She last took it at 8 AM, when should she take it again?</td>
<td>.95</td>
<td>-3.34</td>
</tr>
<tr>
<td>8. John’s insurance has a deductible of $300. On his last visit to the hospital, he was charged $600 for the doctor’s service, and $700 for the lab works. How much will John’s insurance cover?</td>
<td>.64</td>
<td>-.071</td>
</tr>
<tr>
<td>9. Based on this graph, how many patients of stage 1 breast cancer treatment would survive after 10 years?</td>
<td>.81</td>
<td>-1.74</td>
</tr>
<tr>
<td>10. The above label is the nutrition fact for a can of black-eyed peas. If Mike needs 22g of dietary fiber daily, how many servings of black-eyed peas should he take?</td>
<td>.83</td>
<td>-1.89</td>
</tr>
<tr>
<td>11. Based on the graph above, which treatment plan is least effective?</td>
<td>.90</td>
<td>-2.56</td>
</tr>
</tbody>
</table>
12. If Thomas is 5.9 feet tall, and weighs 145 pounds, based on the Body Mass Index above, which range does Thomas falls under? .61 -0.55

13. 1 in 200 people experience nausea after taking a medication. What is the probability of this side effect? .57 -0.39

14. After cataract surgery, the chance of capsular opacification (second cataract) is about 20%. Laser treatment has a 100% success rate at treating this. Out of 100 patients who took cataract surgery, how many of them would develop capsular opacification? .88 -2.35

15. Research show that treatment plan A for arthritis was 70% effective, and treatment plan B was 65%. However, the difference was not statistical significant. Which treatment plan is more effective? .14 2.15

16. A doctor gave anti-depressant A to 100 people with depression, and gave anti-depressant B to 100 randomly selected patients from a hospital. The doctor found the group who took medicine B were less depressed. Can this doctor conclude medicine B is more effective? Why? .68 -0.89

*Notes. For items 9, 10, 11, 12, please see Appendix B for the graphs.*
Table 3

Means, standard deviations, and correlations of measured variables in Study 1

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>58.24</td>
<td>8.33</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Health Numeracy (Full)</td>
<td>12.09</td>
<td>2.63</td>
<td>.127*</td>
<td>.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Health Numeracy (Refined)</td>
<td>4.31</td>
<td>1.56</td>
<td>.144*</td>
<td>.899**</td>
<td>.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. General Numeracy</td>
<td>4.93</td>
<td>1.83</td>
<td>.056</td>
<td>.567**</td>
<td>.484**</td>
<td>.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Subjective Numeracy</td>
<td>36.66</td>
<td>7.48</td>
<td>-.048</td>
<td>.158*</td>
<td>.063</td>
<td>.265**</td>
<td>.82</td>
<td></td>
</tr>
<tr>
<td>6. Medical Decision Making</td>
<td>2.18</td>
<td>1.29</td>
<td>.071</td>
<td>.544**</td>
<td>.558**</td>
<td>.428**</td>
<td>.082</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes. * p < .05, ** p < .01
The coefficients on the diagonal in bold are the Cronbach’s alpha of each scale.
Table 4  

*Coefficients Variables Resulting from Multiple Regression Analysis*

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Constant</td>
<td>-.177</td>
<td>.216</td>
</tr>
<tr>
<td>Refined Health Numeracy</td>
<td>.379</td>
<td>.048</td>
</tr>
<tr>
<td>General Numeracy</td>
<td>.146</td>
<td>.041</td>
</tr>
</tbody>
</table>

*Note.* Dependent variable: number of correct choices in the Medicare Part D task.
Table 5

*Background Information for Study 2 (N = 108)*

<table>
<thead>
<tr>
<th>Survey Items</th>
<th>Descriptive</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Min = 45 yrs. Max = 75 yrs. Mean = 61.88 yrs. SD = 5.63 yrs.</td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>Male: n = 44 Female: n = 64</td>
<td></td>
</tr>
<tr>
<td><strong>Native Language</strong></td>
<td>English: n = 108</td>
<td></td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td>Single: n = 16 Married: n = 59 Divorced: n = 25 Widowed: n = 8</td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Background</strong></td>
<td>African American: n = 4 Asian: n = 98 Caucasian: n = 4 Asian: n = 8</td>
<td></td>
</tr>
<tr>
<td><strong>Highest Degree Received</strong></td>
<td>High School: n = 19 Associate: n = 21 Bachelor’s: n = 35 Advanced: n = 32 Other: n = 1</td>
<td></td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td>Below $20,000: n = 9 $20,000 - $40,000: n = 22 $40,000 - $60,000: n = 23 Above $60,000: n = 53</td>
<td></td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td>Poor: n = 1 Fair: n = 17 Good: n = 56 Excellent: n = 34</td>
<td></td>
</tr>
<tr>
<td><strong>Chronic Disability</strong></td>
<td>No: n = 104 Yes: n = 4</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B. BACKGROUND QUESTIONNAIRE

The Background Questionnaire
(Please circle your choice)

1. Age: _______________________

2. Gender: M F

3. Marital Status: 
   Single    Married    Divorced    Widowed

4. Ethnic Background: 
   African-American
   Caucasian
   Hispanic
   Native American
   Asian
   Other (Specify): _______________________

5. What is your first language? ______________

6. Highest Degree Received: _______________________

7. Occupation: _______________________

8. Major in college: _______________________

9. Annual household income 
   1. Below $20,000
   2. $20,000 - $40,000
   3. $40,000 - $60,000
   4. Above $60,000

10. How would you rate your overall health at the present time? 
    Poor    Fair    Good    Excellent

11. Have you been diagnosed with stroke, neurological or psychiatric disorder, head injury, and/or dementia? 
    No    Yes (Specify): _______________________

1. Your doctor told you to take Tylenol if your temperature reaches 101 degrees. Your current reading is 100.5. Do you need to take Tylenol?

2. You are on a monthly prescribed medicine. You just filled it today. Roughly how many more days are there before you have to refill the medicine?

3. For diastolic blood pressure, less than 80 is normal, between 80 and 89 indicates prehypertension, 90 or above is considered to be hypertension. Joseph’s most recent blood pressure test reads 117/76. Does Joseph have hypertension?

4. Two sites are available for a treatment. Your insurance will cover 80% of expenses from site A and .85 of expenses from site B. Which site is more advantageous?

5. A prescribed medicine costs $50 to fill. Your insurance covers 90% of the total price. How much do you need to pay out of your own pocket?

6. Frank needs to take Bromocriptine for his Parkinson’s disease. The recommended dosage is 5 mg/day. Bromocriptine comes in 2.5 mg pills. How many pills should Frank take each week?

7. Maria needs to take a medication every 8 hours. She last took it at 8 AM, when should she take it again?

8. John’s insurance has a deductible of $300. On his last visit to the hospital, he was charged $600 for the doctor’s service, and $700 for the lab works. How much will John’s insurance cover?

9. Based on this graph\textsuperscript{1}, how many patients of stage 1 breast cancer treatment would survive after 10 years?

---

\textsuperscript{1} Hall, 2016
10. The above label is the nutrition fact for a container of black-eyed peas. If Mike needs 8g of dietary fiber daily, how many servings of black-eyed peas should he take?

11. Based on the graph above, which treatment plan is least effective?
12. If Thomas is 5.9 feet tall, and weighs 145 pounds, based on the Body Mass Index above, which range does Thomas falls under?

13. 1 in 200 people experience nausea after taking a medication. What is the probability of this side effect?

14. After cataract surgery, the chance of capsular opacification (second cataract) is about 20%. Laser treatment has a 100% success rate at treating this. Out of 100 patients who took cataract surgery, how many of them would develop capsular opacification?

15. Research show that treatment plan A for arthritis was 70% effective, and treatment plan B was 65%. However, the difference was not statistical significant. Which treatment plan is more effective?

16. A doctor gave anti-depressant A to 100 people with depression, and gave anti-depressant B to 100 randomly selected patients from a hospital. The doctor found the group who took medicine B were less depressed. Can this doctor conclude medicine B is more effective? Why?
APPENDIX D. ABBREVIATED NUMERACY SCALE

Instructions: Please answer the questions below. Do not use a calculator but feel free to use the space available for notes. It is not timed.

1. Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up as an even number?

   Answer: ______________

2. In the BIG BUCKS LOTTERY, the chances of winning a $10.00 prize are 1%. What is your best guess about how many people would win a $10.00 prize if 1,000 people each buy a single ticket from BIG BUCKS?

   Answer: ______________

3. In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets of ACME PUBLISHING SWEEPSTAKES win a car?

   Answer: ______________

4. If the chance of getting a disease is 10%, how many people out of 1000 would be expected to get the disease?

   Answer: ______________
5. If the chance of getting a disease is 20 out of 100, this would be the same as having a 
_______% chance of getting the disease.

Answer: ________________

6. Suppose your friend just had a mammogram. The doctor knows from previous studies 
that, of 100 women like her, 10 have tumors and 90 do not. Of the 10 who do have 
tumors, the mammogram correctly finds 9 with tumors and incorrectly says that 1 does 
not have a tumor. Of the 90 women without tumors, the mammogram correctly finds 80 
without tumors and incorrectly says that 10 have tumors. The table below summarizes 
this information. Imagine that your friend tests positive (as if she had a tumor), what is 
the likelihood that she actually has a tumor?

<table>
<thead>
<tr>
<th></th>
<th>Tested Positive</th>
<th>Tested Negative</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actually has a tumor</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Does not have a tumor</td>
<td>10</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>totals</td>
<td>19</td>
<td>81</td>
<td>100</td>
</tr>
</tbody>
</table>

Answer: ________________

7. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much 
does the ball cost?

Answer: ________________

8. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 
days for the patch to cover the entire lake, how long would it take for the patch to cover 
half of the lake?

Answer: ________________
APPENDIX E. SUBJECTIVE NUMERACY SCALE

For each of the following questions, please check the box that best reflects how good you are at doing the following things:

1. How good are you at working with fractions?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Not at all good Extremely good

2. How good are you at working with percentages?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Not at all good Extremely good

3. How good are you at calculating a 15% tip?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Not at all good Extremely good

4. How good are you at figuring out how much a shirt will cost if it is 25% off?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Not at all good Extremely good

5. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Not at all helpful Extremely helpful

6. When people tell you the chance of something happening, do you prefer that they use words (“it rarely happens”) or numbers (“there’s a 1% chance”)?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Always Prefer Words Always Prefer Numbers

7. When you hear a weather forecast, do you prefer predictions using percentages (e.g., “there will be a 20% chance of rain today”) or predictions using only words (e.g., “There is a small chance of rain today”)?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Always Prefer Percentages Always Prefer Words

8. How often do you find numerical information to be useful?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6
   Never Very Often
APPENDIX F. MEDICARE PART D DECISION TASK

Card A

<table>
<thead>
<tr>
<th>Plan</th>
<th>Total combined annual cost</th>
<th>Mail order</th>
<th>number of pharmacies</th>
<th>Distance to closest pharmacy (miles)</th>
<th>Annual deductible</th>
<th>Monthly cost share</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4860</td>
<td>1</td>
<td>14</td>
<td>3</td>
<td>0</td>
<td>140</td>
</tr>
<tr>
<td>B</td>
<td>5230</td>
<td>2</td>
<td>13</td>
<td>6</td>
<td>0</td>
<td>160</td>
</tr>
<tr>
<td>C</td>
<td>4530</td>
<td>1</td>
<td>20</td>
<td>4</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>D</td>
<td>7020</td>
<td>2</td>
<td>16</td>
<td>10</td>
<td>250</td>
<td>420</td>
</tr>
<tr>
<td>E</td>
<td>5140</td>
<td>1</td>
<td>20</td>
<td>8</td>
<td>100</td>
<td>210</td>
</tr>
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<td>0</td>
<td>220</td>
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<tr>
<td>G</td>
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<td>16</td>
<td>9</td>
<td>250</td>
<td>270</td>
</tr>
<tr>
<td>H</td>
<td>6740</td>
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<td>14</td>
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<tr>
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<td>18</td>
<td>1</td>
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<tr>
<td>K</td>
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<td>12</td>
<td>2</td>
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<td>240</td>
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<tr>
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<td>130</td>
</tr>
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<td>M</td>
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<td>6</td>
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<td>230</td>
</tr>
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<td>6870</td>
<td>1</td>
<td>19</td>
<td>7</td>
<td>100</td>
<td>310</td>
</tr>
<tr>
<td>O</td>
<td>4990</td>
<td>2</td>
<td>21</td>
<td>8</td>
<td>100</td>
<td>210</td>
</tr>
<tr>
<td>P</td>
<td>5250</td>
<td>1</td>
<td>16</td>
<td>1</td>
<td>100</td>
<td>220</td>
</tr>
<tr>
<td>Q</td>
<td>4950</td>
<td>1</td>
<td>12</td>
<td>3</td>
<td>0</td>
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<td>R</td>
<td>4800</td>
<td>2</td>
<td>16</td>
<td>6</td>
<td>50</td>
<td>170</td>
</tr>
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<td>13</td>
<td>15</td>
<td>0</td>
<td>180</td>
</tr>
<tr>
<td>T</td>
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<td>1</td>
<td>15</td>
<td>7</td>
<td>0</td>
<td>420</td>
</tr>
</tbody>
</table>

**Total combined annual cost:** When you have Medicare prescription drug coverage, you pay part of the costs, and Medicare pays part of the costs. Your total combined annual cost is the total amount of money you are likely to spend in a year, including monthly drug premiums, the annual deductible, the monthly cost share, and other amounts not covered by Medicare.

**Mail order:** This indicates whether you can receive prescriptions in the mail. You are still allowed to go to the pharmacy to pick up your prescriptions.

**Number of pharmacies:** Prescription drug plans contract with pharmacies in your area. Card A shows the number of pharmacies in your area from which you can fill your prescriptions.

**Distance to closest pharmacy:** Prescription drug plans contract with pharmacies in your area. Card A shows the number of miles between your home and the closest pharmacy.

**Annual deductible:** The amount you will have to pay first for your prescription drugs each year before your plan starts to pay.

**Monthly cost share:** The amount you pay for each prescription after you have paid the annual deductible.
Questions of Paper-and-Pencil Tasks for Drug Plan Choice

We start by presenting you with a hypothetical situation. Please read the following carefully and answer the questions that follow using only the information you gained by reading the example.

Imagine that one of your friends, whom we’ll call Bill, has asked you to help him in choosing a Medicare prescription drug plan. He has made it clear that he is only concerned about saving money and therefore would like to enroll in the plan that minimizes his total combined annual cost for prescription drugs and the insurance for those drugs. We will provide you with a card containing information about several insurance companies covering prescription drugs.

After you review this information in Card A, you will be asked several questions. Please choose the answer which you think is the best one.

We will also provide you with a card containing the definitions of various terms used throughout this experiment that can help you in answering the questions.

If you have any questions during the study, do not hesitate to ask a member of the project team.

Please answer the following questions using Card A:

1. Given Bill’s desire to minimize total annual cost of prescription drugs, which one of the drug plans listed on Card A would you recommend that he choose? Please write down the Company Letter.

   Company Letter _____________

2. Thinking about your decision on Question 1, please indicate how confident you are that your decision is a good one.

   Provide a rating from 1 to 5, using the following scale. Please circle only one number. (1 = Not confident at all, 5 = Very confident)

3. Looking at the information in Card A, which company has the largest number of pharmacies? Please write down the Company Letter.

   Company Letter _____________

4. Looking at the information in Card A, what is your opinion about the number of companies offering prescription drug coverage? Please circle only one number. (1 _ Not enough choice, 5 _ Too much choice)

5. Which of the companies listed does NOT offer mail order but has the closest pharmacy location? Please write down the Company Letter.

   Company Letter _____________

6. Thinking about the questions you just answered, how hard was it for you? Please circle only one number. (1 = not hard at all, 5 = very hard)

   Continued
Now suppose that another friend, whom we’ll call Linda, has also asked you for help with choosing a Medicare prescription drug plan. Unlike Bill, Linda is interested in purchasing a policy that both has low total combined annual cost AND also allows policyholders to order their medication by mail. Please refer again to Card A when answering the following questions.

**Please answer the following questions using Card A:**

7. Given Linda’s desire to minimize the total combined annual cost for prescription drugs AND to buy one that allows receiving the drugs through mail order, which one of drug plans listed on Card A would you recommend she choose? Please write down the Company Number.

   Company Letter _____________

8. Thinking about your decision on Question 7, please indicate how confident you are that your decision is a good one.

   Provide a rating from 1 to 5 using the following scale. Please circle only one number. (1 = Not confident at all, 5 = Very confident)

9. Thinking about the questions you just answered (Questions 7 and 8), how hard was it for you? Please circle only one number. (1= Not hard at all, 5 =Very hard)
APPENDIX G. CONSENT FORM AGE 44-45

CONSENT FORM AGE 45-55

Purpose

I am Jiaxi Wang, a graduate student at the Psychology Department of Bowling Green State University. You are invited to participate in a study that examines age differences in health numeracy. Specifically, we wish to gain more understanding on the relationship between age, health numeracy, and medical decision making competence.

Procedure

You will need to be between 45 and 55 years of age and can communicate in English to participate. You will need to fill out a background questionnaire, followed by two numeracy scales, and finally a medical decision making task. The whole process should take about 30 minutes to complete.

Benefits

By participating, you will have a chance to win one of the twenty $20 Amazon gift cards after the data collection process is done. Your chance of winning is 1/6. If you wish to enter the drawing, you will need to provide your contact information at the end of this consent form. You will be contacted if you are selected to receive the gift card. Please note that your contact information will not be associated with your responses in the study in any way, and it will be destroyed after the study is complete.

CERTIFICATION OF INFORMED CONSENT

The procedure for this study has been described to me. I have been informed that this study involves no risks to physical or mental well-being beyond those risks encountered in normal everyday life. I am aware that by participating I will have a chance to win a $20 Amazon gift card.

I am aware that all data will be kept strictly anonymous. My name will not be collected from any of the questionnaires. This consent form, which contains my name and contact information, will be kept separately from the rest of data in a secure place. I have been informed that after the gift cards have been given away, my contact information will be detached from this form and be destroyed. I have been informed that the data will be kept in a password protected hard disk only accessible to the principal investigator. I have been informed that my participation in this study is entirely voluntary and I am free to withdraw at any time without penalty. I have been informed that by accepting or refusing to participate, my relationships with BGSU will not be harmed.

I have been informed that I may contact the principal investigator, Jiaxi Wang, at (740)214-6119 or jwang@bgsu.edu and his advisor Dr. Yiwei Chen, at (419)372-2462 or ywchen@bgsu.edu for research questions, and contact the chair of the Human Subjects Review Board at (419)372-7716 or hsrb@bgsu.edu for any questions or concerns about my rights as a research participant.

I, ________________________ (Print), agree to participate in this study.

__________________________________________ ___________
Participant’s Signature Date
Please write down your contact information (such as phone number or email address) in the spaces below. So that you can be reached by the principal investigator if you win one of the gift cards. Your contact information can only be accessed by the principal investigator. After the gift cards have been handed out, your contacted information will be detached from this page and be destroyed by the principal investigator.
APPENDIX H. CONSENT FORM AGE 55-65

CONSENT FORM AGE 55-65

Purpose
I am Jiaxi Wang, a graduate student at the Psychology Department of Bowling Green State University. You are invited to participate in a study that examines age differences in health numeracy. Specifically, we wish to gain more understanding on the relationship between age, health numeracy, and medical decision making competence.

Procedure
You will need to be between 55 and 65 years of age and can communicate in English to participate. You will need to fill out a background questionnaire, followed by two numeracy scales, and finally a medical decision making task. The whole process should take about 30 minutes to complete.

Benefits
By participating, you will have a chance to win one of the twenty $20 Amazon gift cards after the data collection process is done. Your chance of winning is 1/6. If you wish to enter the drawing, you will need to provide your contact information at the end of this consent form. You will be contacted if you are selected to receive the gift card. Please note that your contact information will not be associated with your responses in the study in any way, and it will be destroyed after the study is complete.

CERTIFICATION OF INFORMED CONSENT

The procedure for this study has been described to me. I have been informed that this study involves no risks to physical or mental well-being beyond those risks encountered in normal everyday life. I am aware that by participating I will have a chance to win a $20 Amazon gift card.

I am aware that all data will be kept strictly anonymous. My name will not be collected from any of the questionnaires. This consent form, which contains my name and contact information, will be kept separately from the rest of data in a secure place. I have been informed that after the gift cards have been given away, my contact information will be detached from this form and be destroyed. I have been informed that the data will be kept in a password protected hard disk only accessible to the principal investigator. I have been informed that my participation in this study is entirely voluntary and I am free to withdraw at any time without penalty. I have been informed that by accepting or refusing to participate, my relationships with BGSU will not be harmed.

I have been informed that I may contact the principal investigator, Jiaxi Wang, at (740)214-6119 or jwang@bgsu.edu and his advisor Dr. Yiwei Chen, at (419)372-2462 or ywchen@bgsu.edu for research questions, and contact the chair of the Human Subjects Review Board at (419)372-7716 or hsrb@bgsu.edu for any questions or concerns about my rights as a research participant.
I, ________________________ (Print), agree to participate in this study.

__________________________________________ ___________
Participant’s Signature Date
Please write down your contact information (such as phone number or email address) in the spaces below. So that you can be reached by the principal investigator if you win one of the gift cards. Your contact information can only be accessed by the principal investigator. After the gift cards have been handed out, your contacted information will be detached from this page and be destroyed by the principal investigator.
**APPENDIX I. CONSENT FORM 65-75**

**CONSENT FORM AGE 65-75**

**Purpose**

I am Jiaxi Wang, a graduate student at the Psychology Department of Bowling Green State University. You are invited to participate in a study that examines age differences in health numeracy. Specifically, we wish to gain more understanding on the relationship between age, health numeracy, and medical decision making competence.

**Procedure**

You will need to be between 65 and 75 years of age and can communicate in English to participate. You will need to fill out a background questionnaire, followed by two numeracy scales, and finally a medical decision making task. The whole process should take about 30 minutes to complete.

**Benefits**

By participating, you will have a chance to win one of the twenty $20 Amazon gift cards after the data collection process is done. Your chance of winning is 1/6. If you wish to enter the drawing, you will need to provide your contact information at the end of this consent form. You will be contacted if you are selected to receive the gift card. Please note that your contact information will not be associated with your responses in the study in any way, and it will be destroyed after the study is complete.

**CERTIFICATION OF INFORMED CONSENT**

The procedure for this study has been described to me. I have been informed that this study involves no risks to physical or mental well-being beyond those risks encountered in normal everyday life. I am aware that by participating I will have a chance to win a $20 Amazon gift card.

I am aware that all data will be kept strictly anonymous. My name will not be collected from any of the questionnaires. This consent form, which contains my name and contact information, will be kept separately from the rest of data in a secure place. I have been informed that after the gift cards have been given away, my contact information will be detached from this form and be destroyed. I have been informed that the data will be kept in a password protected hard disk only accessible to the principal investigator. I have been informed that my participation in this study is entirely voluntary and I am free to withdraw at any time without penalty. I have been informed that by accepting or refusing to participate, my relationships with BGSU will not be harmed.

I have been informed that I may contact the principal investigator, Jiaxi Wang, at (740)214-6119 or jwang@bgsu.edu and his advisor Dr. Yiwei Chen, at (419)372-2462 or ywchen@bgsu.edu for research questions, and contact the chair of the Human Subjects Review Board at (419)372-7716 or hsrb@bgsu.edu for any questions or concerns about my rights as a research participant.

I, ________________________ (Print), agree to participate in this study.

__________________________________________
Participant’s Signature Date
Please write down your contact information (such as phone number or email address) in the spaces below. So that you can be reached by the principal investigator if you win one of the gift cards. Your contact information can only be accessed by the principal investigator. After the gift cards have been handed out, your contacted information will be detached from this page and be destroyed by the principal investigator.