Numeracy and Decision Making

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Abstract
Numeracy pertains to a person's ability to understand numbers. A person's level of numeracy is developed as soon as they enter into grade school. During that stage, people are learning the basic and essential mathematical skills associated with building their numeracy. When numeracy is associated with higher education, this focuses on adults and how they understand numbers. Adults are also viewed as being numerate or innumerate. Numerate means having a high level of understanding when using numbers while innumerate means having a low level of understanding when using numbers.

A person's level of numeracy becomes important when facing real world situations and problems. This is most commonly found in situations pertaining to probability and chance. Probability and chance become a main focus every day because as soon as a person wakes up, they begin making decisions and weighing their options. These decisions can range from something small such as deciding what to wear to something large such as scheduling what time to take certain medications. Numeracy is essential for everyday life considering there are many factors that can affect a person's decision-making skills.

Key Words
Numeracy, Probability, Judgement, Mathematics, Decision Making

Introduction

Numeracy can be defined as the ability to process basic probability and numerical concepts [1]. Following this definition, people can be numerate which means they understand mathematical concepts, or they can be innumerate which mean they do not fully understand mathematical concepts. Numeracy mainly focuses on probability and chance. This becomes important when making decisions in every day life. One common strategy that is commonly found in numeracy problems is framing. Framing means that a problem is given to someone and it is related to a real world problem, such as health risks, and influences someone to favor one side over the other. Those with higher numeracy, have a reduced level of susceptibility to the framing of problems, are less influenced by nonnumeric information, and are more sensitive to various levels of numerical risks [2].

Statement of Purpose

The purpose of this research is to identify what numeracy is, how it pertains to every day life, and why it is important in higher education. This research will also examine how participants respond to a series of questions related to determining their level of numeracy how they make decisions. In order to collect data, we have created a survey that asks for the participants demographics followed by a series of numeracy questions from previous studies related to mathematics, probability, judgment, and quantities. The survey and questions will be made available to the participants through Qualtrics and Mechanical TURK (MTURK), an online surveying system.

Research Questions

1. How does numeracy relate to decision-making?
2. How do reaction times affect judgment and decision-making?

Methodology

This study was based on 4 previous studies by Ellen Peters (et. al) that focused on a series of questions intended to measure a persons level of numeracy. The questions used in the survey were based on two scales, the Lipkus scale and the Berlin Scale. These two scales consisted of questions that were based on probability, chance, quantitative representation, judgement, and rating. Approaches that contributed to the judgement and decision-making tasks were attribute framing, risk representation, affective information, and betting.

We also gave questions and a vignette that related number representation to real life situations in order to show the application of numbers and to see how the participants interpreted the information. In order to get a broad selection of results, we created a survey in Qualtrics. This allowed us to edit the type of responses we needed from the participants, whether the questions were multiple choice, open-ended response, or a rating scale.

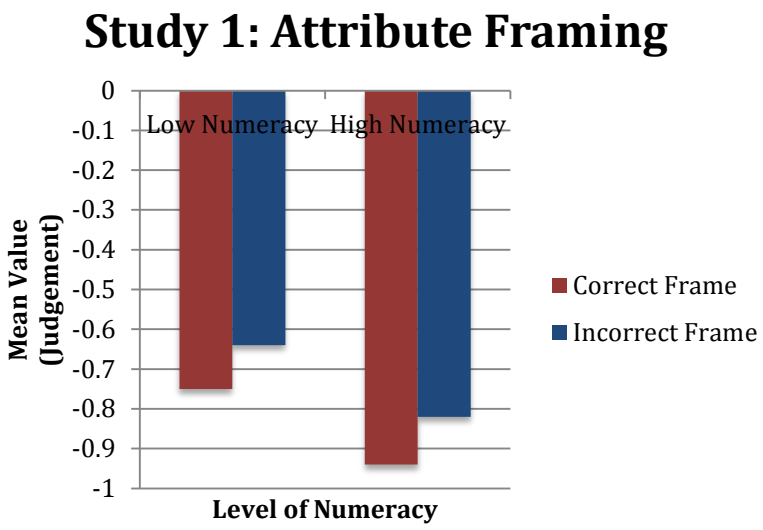
Research Participants

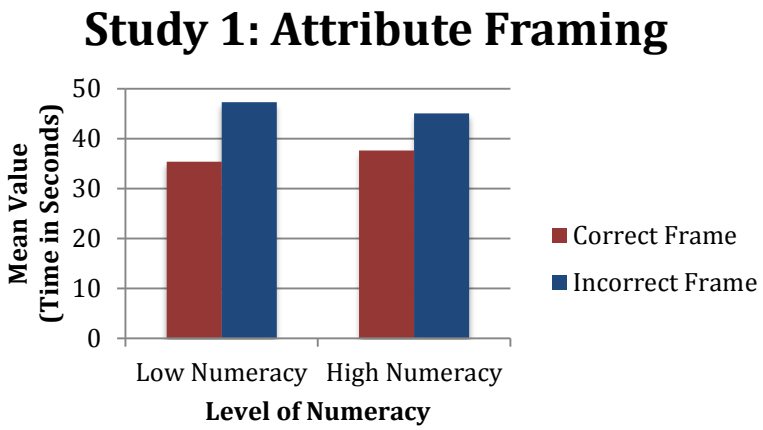
Our research consisted of a total of 234 participants that varied in age from 18 and older. The data represented is from the 222 participants who attempted all or a majority of the research questions. The frequency of our zscore was 12 since these were the participants that were three or more standard deviations from the mean. One of the requirements was that the participants must currently live in the United States. Most of the participants were also fluent in English, which included 97.4%. 37.6% of the participants were males, 61.5% of the participants were females, and one participant preferred not to answer. The levels of education of the participants included 11.6% at the high school level, 75.6% at the college level, 11.6% at the graduate level, and two participants preferred not to answer. A majority of the participants were white, totaling at 73.5%, while the rest of the participants were 8.5% black, 4.7% Hispanic, 8.1% Asian, and 5.2% were other race. The participants were able to be part of this study by voluntarily selecting the link in an ad provided by MTURK. All of the demographics of each participant were also accounted for at the beginning of the survey. Each participant was also given the same number of questions regardless of the wording of the questions. Depending on how many questions the participant answered, their data was excluded from the final results.

Data Collection and Results

Study 1- Attribute Framing

In this study, participants rated the performance of a students test grades. The rating scale ran from “very poor” to “very good”. They were either given the percent correct or incorrect of the students test scores. The charts represent the mean value of the participants’ judgment and their reaction times.





Judgment:

High numerate participants rated the students' grades significantly lower than did the low numerate people, $F(1,218) = 4.529$, MSE = .397, $p = .034$, ES = .020.

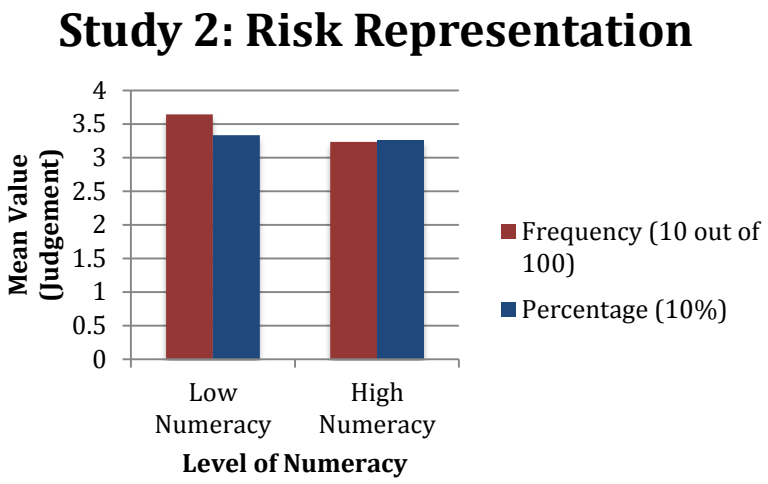
The framing of the students' grades did not affect participants' ratings of those grades, $F(1,218) = 1.842$, MSE = .397, $p = .176$, ES = .008.

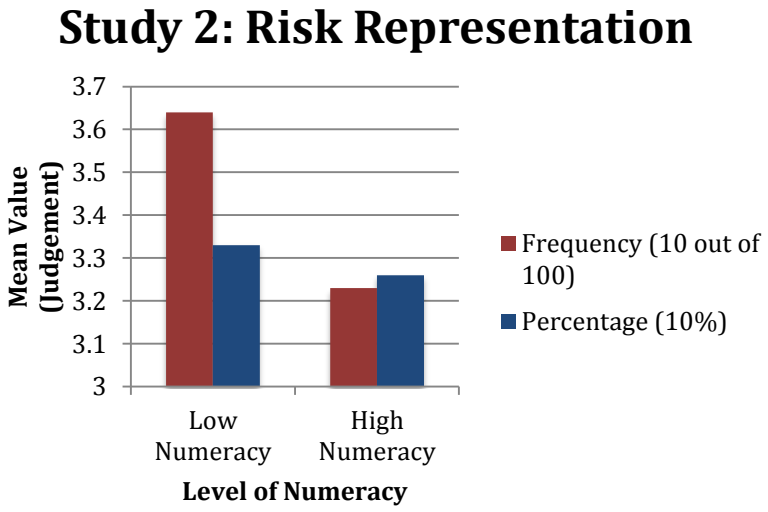
The interaction of numeracy and framing was not significant, $F(1,218) = .010$, MSE = .397, $p = .919$, ES < .001.

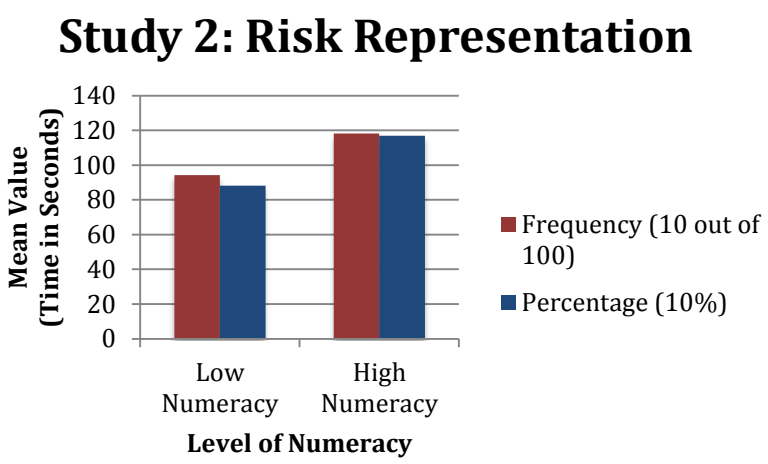
Study 2- Risk Representation

In this study, participants were given a vignette of a mental health patient that was being discharged. After reading the vignette, the participants had to

rate the level of risk of the patient committing an act of violence given a scale that ran from "very low risk" to "very high risk". The participants were either given the level of risk as a percent or a frequency. The charts represent the mean value of the participants' judgment and their reaction times.







Judgment:

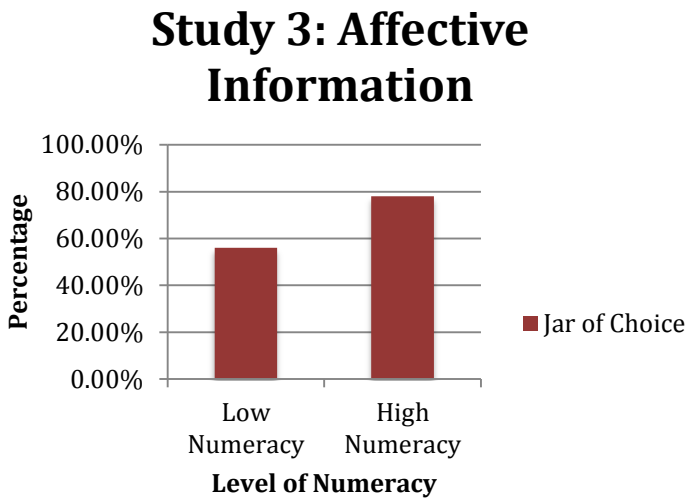
High and low numerate participants perceived an equivalent risk of violence, $F(1,218) = 2.459$, MSE = 1.234, $p = .118$, ES = .011.

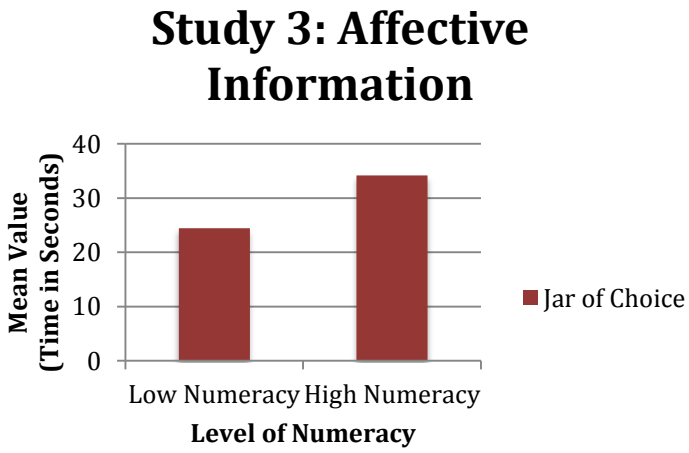
The numerical representation of the patients' chances of violent behavior was not affected by the framing of the risk in terms of frequency versus percentage, $F(1,218) = .791$, MSE = 1.234, $p = .375$, ES = .004.

The interaction of numeracy and numerical representation was not significant, $F(1,218) = 1.242$, MSE = 1.234, $p = .266$, ES = 0.006.

Study 3- Affective Information

In this study, participants were given two jars of jellybeans. Jar A had 9 red jellybeans out of 100 and jar B had 1 red jellybean out of 10. The participants had to choose which jar they believed had the higher chance of them picking a red jellybean. The charts represent the mean value of the participants' judgment and their reaction times.



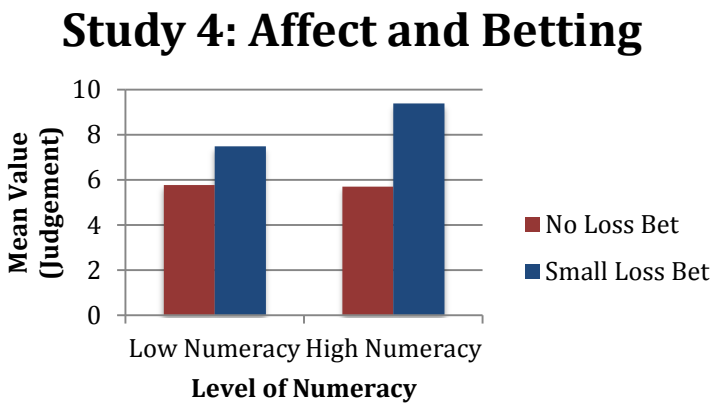


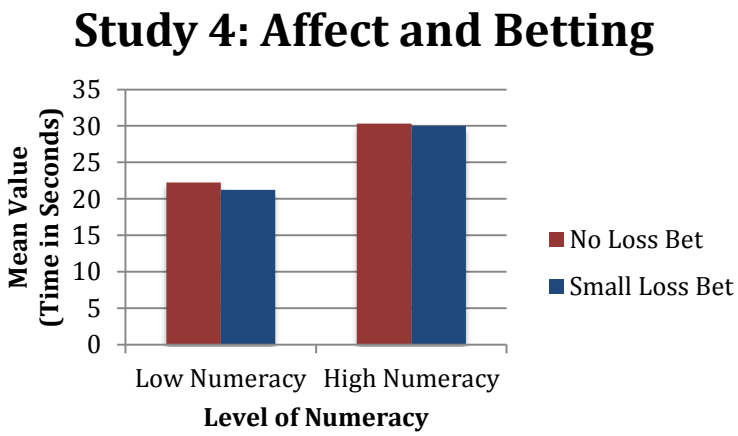
Judgment:

High numerate participants were more likely to choose the jar with fewer jelly beans (greater chance of winning) than were the low numerate participants, $F(1,220) = 12.752$, MSE = .203, $p < .001$, ES = .055.

Study 4- Affect and Betting

In this study, participants were either given a no loss or small loss bet. The no loss bet presented to the participants was that they had a 7/36 chance to win $9 or 29/36 chance to win nothing. The small loss bet presented to the participants was that they had a 7/36 chance to win $9 or 29/36 chance to lose $0.05. Given one of the bets, the participants had to rate the attractiveness of the bet on a scale from "0- not attractive at all" to "20- extremely attractive". The charts represent the mean value of the participants' judgment and their reaction times.





Judgment:

High and low numerate participants perceived equal attractiveness of the bets, $F(1,217) = 1.470$, $MSE = 30.446$, $p = .227$, $ES = .007$.

Participants rated a bet involving a small potential loss as more attractive than a bet involving no chance of a loss, $F(1,217) = 12.742$, $MSE = 30.446$, $p < .001$, $ES = .055$.

The interaction of numeracy and the presence or absence of a loss was not significant, $F(1,217) = 1.689$, $MSE = 30.446$, $p = .195$, $ES = .008$.

Conclusion

For a majority of our studies, our expectations did not come out correct. We expected that the level of each person's numeracy would affect how he or she responded to the scenarios presented in each of the studies. For study two, we concluded that participants may have taken longer to read the

vignette or may have taken a break during the study since the response times were significantly larger than the average response times on the other three studies. Overall, we came to the conclusion that an individual's level of numerical understanding affects how they make judgments in various situations. These decisions become essential when making decisions such as those related to our study. This can include choosing between two options, rating the attractiveness of a situation, or judging a risky or health related situation.

Future Work

Future research efforts include discovering how loss averse someone is based on how they feel when they will lose something in a given situation. Loss aversion pertains to how a person feels when the loss outweighs the gain. This includes using various scales to measure the participants' emotions about the gain or loss. This includes the following scales: bipolar, unipolar intensity, 3-point relative intensity, 9-point relative intensity scale [3]. This is also an extension of study 4, when the participant is given a win or lose scenario. Also, a new study will be run and will be an edited version of the first studies presented in this research paper. The new study will also include questions pertaining to loss aversion.

Acknowledgements

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References

1. Peters, E., Västfjäll, D., Slovic, P., Mertz, C., Mazzocco, K. and Dickert, S. (2006). Numeracy and Decision Making. *Psychological Science*, 17(5), pp.407-413.
2. Peters, E. (2012). Beyond Comprehension. *Current Directions in Psychological Science*, 21(1), pp.31-35.
3. McGraw, A., Larsen, J., Kahneman, D. and Schkade, D. (2010). Comparing Gains and Losses. *Psychological Science*, 21(10), pp.1438-1445.
4. Slovic, P., Monahan, J. and MacGregor, D. (2000). Violence risk assessment and risk communication: The effects of using actual cases,

providing instruction, and employing probability versus frequency formats. *Law and Human Behavior*, 24(3), pp.271-296.
5. Cokely, E., Galesic, M., Schulz., Ghazal S., and Garcia-Retamero, R. (2012). Measuring Risk Literacy: The Berlin Numeracy Test. *Judgement and Decision Making*, 7(1), pp. 25-47.