# ROULETTE AND DECISION MAKING

## TO WHAT EXTENT DOES THE INCLUSION OF RISK INFORMATION LEAD TO LOSING LESS WHEN BETTING?

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**Roulette and decision making: To what extent does the inclusion of risk information lead to losing less when betting?**

Abstract:

Dangerous gambling is a great cost to many individuals and to society at large. One possible solution to this problem is ensuring that consumers are better informed through displaying the probability of winning. This quantitative study explores whether the addition of risk information can lead to losing less in gambling situations, and which type of risk information participants consider to be the most helpful. Using an survey with an experimental design, participants were presented with gambling situations and their decision making was observed in order to provide data regarding to which extent different types of risk information: (1) a verbal descriptor of the chance of winning, (2) percentage probability of winning and (3) frequency probability of winning, affected decision making and winnings. The findings show that those who received risk information via percent are more likely to attain a higher final balance in the roulette game, playing more winning bets and fewer losing bets on average. Numeracy and the complexity behind decision making were also shown to have effect on final balance, meaning that they are important factors behind losing less.

Keywords:

Decision making, Gambling, Numeracy, Risk perception, Roulette, Casino, Betting, Risk information

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# Table of Contents

# 1. Introduction

## 1.1. Background

The global gambling market is already a huge market. Yet, it is expected to grow from USD 465.76 billion in 2020 to USD 516.03 billion in 2021 (Global Gambling Market Report, 2021). On January 1, 2019 the Swedish gaming market underwent significant change as parts of the former monopoly opened up for competition. Since then over 100 gaming licenses, required in order to conduct business in the Swedish gambling market, have been issued by the Swedish Gaming Inspectorate (Spelbolag med spellicens, 2021). Further, the gambling market in Sweden had profits of SEK 24.8 billion in 2019.

Approximately 60 percent of all Swedes state that they have gambled for money in the last 12 months and around four percent of the whole population suffers from gambling addiction (Fakta om spelbranschen, 2021). A higher proportion of problem players in Sweden are found among the players who bet online regardless of which form of gambling they lay money on (Folkhälsomyndigheten, 2018). There are concerns that the pandemic Covid-19 might increase the risk of gambling problems even further due to e.g. economic problems and heavier computer usage (Gross Hulth, 2021). Moreover, people who suffer from a gambling disorder have an elevated risk of mortality as well as mortality by suicide. Karlsson & Håkansson (2018) found that the suicide rate was 15 times higher when having a gambling disorder compared with the general population. Gambling problems evidently cause lots of distress and agony for the affected and their related parties. However, it also entails great costs for Swedish society. The estimated cost is around SEK 14 billion every year (Svensson, 2020).

Today there are no regulations in Sweden regarding risk information in gambling. However, in the UK it is compulsory for gaming machines (i.e. slot machines, fruit machines or FOBTs) to clearly display the percentage return-to-player figure (% RTP) or the odds of winning. The machines must also make information available about their category, % RTP and whether they are compensated or random (Gaming machine payouts: return-to-player, n.d.). The Swedish Gambling Law states under their requirements for gaming activities that (1) games must have strong consumer protection, (2) there must be a high level of security in the games, and (3) the negative effects of gambling shall be limited (Riksdagsförvaltningen, 2018). Consequently, this thesis is relevant from a marketing perspective as obligatory risk information in gambling could be an opportunity to further regulate the gambling market and influence consumers in the latter stages of the marketing funnel in order to reduce costs to society.

## 1.2. Problem formulation

In the UK, some foods are labeled with “traffic lights” where e.g. the color red displays high sugar or high fat (Kanter et al., 2018) whilst gambling ads solely have warning texts like “When the fun stops, stop” (Newall et al., 2020). One could argue that these gambling warnings do not help consumers to make a well-informed decision. Newall et al. (2020) also mentions another example where statistical labelling is used in order to guide consumers to make better informed decisions is alcohol labelling. Alcohol is often labelled through the percentage concentration of alcohol (i.e. alcohol by volume, ABV). Although, in the US, UK and Australia, the extent of pure ethanol is also communicated as a metric of standard drinks which makes it possible for consumers to compare e.g. a glass of wine and a glass of beer in terms of amount of ethanol (Hobin et al., 2017).

Seeing that there is plenty of research regarding warnings of other unhealthy habits, while little exists on risk information in gambling has piqued our interest in the subject. Additionally, researchers can prompt how data is perceived by framing it in different ways. For example, saying that 99% of young men in London do not commit extreme youth violence or that 10 000 young men in London do commit extreme youth violence can be perceived very differently, even if they convey the same message (David Spiegelhalter 2019). Hence, it seemed relevant to investigate what type of risk information would be the best possible procedure to safeguard the health of the public whilst making sure that gamblers make informed decisions. The identified problem area that the survey explores is thus the possible effects of risk information whilst gambling.

## 1.3. Purpose and research questions

The main purpose of this thesis is to examine whether risk information affects gambling behavior, and whether it can reduce losing. Additionally, the thesis will investigate whether a certain type of risk information is more favorable to use from a player’s perspective.

Hence, our main research questions were constructed as following:

To what extent does risk information affect decision making whilst gambling?

Does the introduction of risk information reduce the chance of losing?

Additionally, a sub-question was posed:

What type of risk information is rated most favorably by players?

## 1.4. Delimitations

Factors such as the pandemic Covid-19 interfered with having a real-life simulation through e.g. a roulette game or slot machines. Further, due to limited financial resources and time constraints, we had to delimit the scope of work and focus on one type of game. Hence, a survey resembling a roulette game was chosen since the rules of the game can be easily understood by participants that are not familiar with gambling. Moreover, the game roulette is easier to visually present than most other games in a survey format. The experiment only examines the effect of risk warnings in roulette. Therefore, the results cannot be directly applied to all other forms of gambling.

## 1.5. Research gap and contribution

This thesis will examine already existing research regarding gambling, risk perception, warnings in other product fields, and decision making. There is already an extensive amount of research on these subjects as we have seen in the library database. Yet, so far there is little research on how risk information can affect gambling behavior which indicates need for further research in the field. As aforementioned, this might be a new method to better regulate the gambling market in order to minimize the negative costs for both society, players and their related entities.

## 1.6. Disposition

The following paragraphs in the thesis will firstly present the theoretical framework that our hypotheses will be based on. Subsequently, the methodology section will exhibit our quantitative study. In section 4, the empirical results will be outlined followed by a discussion, implications, limitations and suggestions for future research in section 5. Lastly, references and the appendix can be found.

# 2. Theoretical frame of reference

## 2.1. Previous research on gambling

According to Binde (2009) there are indications which often show that internet gambling, slot machines and casino gambling are relatively associated with problem gambling whilst scratch cards and lotteries are not. This is also true for Swedes since studies show that a higher proportion of Swedish problem players are found among the players who bet online regardless of which form of games they play (Folkhälsomyndigheten, 2018). Binde (2019) also disclosed that for some people, gambling advertising extensively contributes to gambling problems.

Binde (2013) describes in his motivational dimension model that there are five main points that seem to motivate gambling: the dream of jackpot, intellectual challenges, the mood benefits it can give, social rewards and the chance of winning. The thrill of beating the odds being one of the core elements of gambling explains the matter why online casino websites with high risk (low certainty) clusters are ranked higher than those with low risk (Konietzny, 2017).

Due to the volatility of gambling, theoretical loss is only relevant in the long-run since short-run results might diverge from the statistics. Ergo, in the long-run, the house always wins. Yet, gamblers may be more focused on their short-term losses and gains than the effects in the long-run (Newall et al., 2020).

## 2.2. Previous research on risk perception

A study made by Harrigan et al. (2017) suggested that giving risk information (presented as house edge) to gamblers on slot machines did not affect the gambling behavior significantly. However, many generic warning labels currently used (e.g., gamble responsibly, gambling is addictive) provide insufficient information to be able to affect gambling behavior (Newall et al., 2020).

Furthermore, Fellbom and Förberg (2019) did not find support for that the presence of warning texts in online casino ads increases the recipient's perceived attitude towards the ad content or affects the recipient's perceived risk assessment of the product. Additionally, a study on alcohol warnings and adolescents found that alcohol warning had no beneficial effect on adolescents' beliefs about alcohol or alcohol-related behaviors (MacKinnon, 2000).

However, Vanepps (2016) found that warning labels about sugar decreased adolescents' likelihood of hypothetically buying sugar-sweetened soft drinks. Further, he found that two of the warning labels even lowered intentions of buying sugary soft drinks in the future while calorie labels did not influence behavioural intentions. Also, David

Spiegelhalter (2019) mentions that things such as language, color, font and order affects how data is interpreted.

How risk is communicated can affect how people understand information about risk. This is shown in a study by Gigerenzer (2003) where he presents that statistical information can be difficult for people to understand due to poor presentation. According to Gigerenzer, using natural frequency statements instead of single event probabilities or conditional probabilities could avoid this confusion and foster insight since it specifies a reference class. Furthermore, when presenting probability in percentage people tend to misunderstand or misinterpret the risk information. People presented with the same information but in frequency seem to understand the information better, especially when paired with visualization (Andersson & Almqvist, 2016). David Spiegelharter (2019) asserts that probability is often misinterpreted due to it sometimes being counterintuitive. McDowell & Jacobs (2017) also saw that when presenting information in natural frequencies instead of in probability it raises performance rates from 4% to 24%. However, when confronting people with natural frequencies, some choose to convert it back to complicated probabilities. Hence, making them less intuitive. (Weber et al., 2018)

## 2.3. Previous research on decision making

Kahneman & Tversky (1979) developed prospect theory which describes how people assess their losses and gains in an asymmetric manner. Prospects theory's fourfold pattern of choice showed that people tend to be (1) risk-averse over high-probability gains, (2) risk-seeking over low-probability gains, (3) risk-seeking over high-probability losses, and (4) risk-averse over low-probability losses. Further, the study pointed out that people have inconsistent preferences when the same choice is presented in different forms. However, Millroth, Nilsson & Juslin (2019) found that the different forms of risk presentation had no effect on modal choices. Moreover, many of the paradoxes are hard to replicate. Still, they found that people low in numeracy tend to make more cautious decisions that concentrate on risk minimization of worst outcomes (Millroth, Nilsson, & Juslin, 2019). Another study shows that choices that have identical risk derive depending on if they are made from experience or description. Experience-based choice may not explicitly use probability theory while description-based decisions are consistent with prospect theory's fourfold pattern of choice (R. Camilleri & R. Newell, 2009).

## 2.4. Hypotheses

**Table 1.** Hypotheses based on the theoretical framework.

| | | |
|---|---|---|
| H1 | Participants will be more confident in their bets when risk is presented in frequencies rather than percentages. | Andersson & Almqvist 2016; McDowell & Jacobs 2017; Gigerenzer 2003 |
| H2 | Participants low in numeracy will be more risk averse. | Millroth, Nilsson, & Juslin, 2019 |
| H3a | Participants will be risk seeking when presented with low probability gains. | Kahneman & Tversky, 1979 |
| H3b | Participants will be risk averse when presented with high probability gains. | Kahneman & Tversky, 1979 |

# 3. Methodology

## 3.1. Scientific approach

The report seeks to investigate whether risk information affects gambling behavior and which type of risk information is the most likely to help players make an informed decision. Hence, a deductive approach was preferable where the hypotheses are formed on existing research (Bryman, Bell, & Harley, 2018).

In order to answer the research questions stated previously, we chose to develop an experimental study. An experiment means that individuals are randomly allocated into various groups to receive different treatments. Thereafter, the results of the separate groups can be compared to determine which effects the different treatments may have compared to the control group (Söderlund, 2018). An experimental design was suitable as the report aimed to investigate whether several types of risk information can affect gambling behavior (as opposed to having no risk information), and which is seen as the most helpful to players. An experimental design also allowed for the survey experience to be more interactive and closer to a real-life gambling environment. The research was carried out through a Qualtrics online survey that had been heavily adjusted to provide an interactive and detailed experiment experience.

Another method to carry out the same research would have been implementing the risk information in real life situations i.e., in online casinos or with slot machines. This would have better resembled the decision making environment that players are in when gambling, as opposed to the online survey environment that we provided. The benefits of such an approach would be a stronger link between the research findings and the expected effects of implementing a risk information requirement for gambling companies, which is the goal of this report (providing that it can help reduce dangerous gambling). Another benefit of employing a “real life” approach is that the respondents are gambling their own money, instead of a fake currency only present in the survey. Considering the circumstances and nature of this report (which were elaborated in “Delimitations”), the authors of the report concluded that the online survey method could serve as an adequate proxy for this method.

## 3.2. Experiment

### 3.2.1. Experiment participants

The survey was distributed between the 27th of March and 28th of April in 2021 and collected a total of 252 responses. Before the survey was distributed, the authors discussed whether to target the public or avid gamblers to collect the most relevant data. On one hand, frequent gamblers are more likely to take gambling decisions and could therefore be aided by receiving more information before each decision. On the other hand, we theorized that experienced gamblers are more likely to know whether a bet has high or low probability of winning because of their understanding of the game. We instead deemed that risk information would likely be more helpful for the public as we believe that they are more likely to make uninformed gambling decisions, which would stem from a lack of experience in such situations. An uninformed gambling decision in this case would be one that is not based upon the probability of winning. The survey was distributed through Facebook, LinkedIn, e-mail, and other social media. Because of this, the respondents make up a so-called convenience sample, which is a skewed representation of the total population in Sweden. We have made efforts to make the sample more complete by contacting groups that have a more even distribution of ages and are of different geographical backgrounds than the authors. The benefit of collecting a convenience sample is a larger volume of answers in a shorter period at a low cost, which was vital for a report of this nature where time is of the essence. A non-representative sample would hurt the replicability of the study, which is discussed in the critical review of the research method.

### 3.2.2. Experiment design

The survey was conducted using an anonymous questionnaire created using the survey-tool Qualtrics. The questions were written in English in order to maintain consistency with the written thesis and the Berlin Numeracy Test used in the questionnaire and to avoid misunderstandings that could occur due to any potential mistranslations. The authors deemed that the risk of having a questionnaire in English whilst targeting Swedish respondents to be negligible, as the content of the survey was written to be easy to understand.

When a respondent began taking the survey, they were welcomed with an introduction screen, which explained the purpose and main contents of the study. It gave an appreciation of the completion time, details about the donation to charity as well as information about the researchers. The participants were instructed to answer to the best of their abilities and to refrain from taking part in the survey if they are suffering or have suffered from a gambling addiction.

In block 1 participant consented to taking the survey regarding GDPR (General Data Protection Regulation) and were subsequently presented the rules of the roulette game. The version of roulette in the survey is a simplified version of its real-life counterpart, further described in the next paragraph. After the instructions, there was a control question to see if the participant had read and understood the rules of roulette. Failing to answer this control question twice would lead to a premature exit of the study. This was done in order to provide assurance that the respondents who passed this initial stage were serious about answering our questions, and to ensure that their gambling decisions were made with an understanding of the rules. The question functioned not dissimilar to an instructional manipulation check (Oppenheimer et al. 2009) to filter out people who answer randomly and/or do not read the instructions of the survey. In the end of block 1 participants were given a few background questions, including birth year, previous gambling experience, risk taking and gender. These questions were used to later analyze how diverse the sample is, as a less diverse sample could lead to a sampling error. To make a more complete sample analysis, the survey should have contained additional questions such as education. The background questions also allowed for testing for correlations between the outcome of the roulette game and the literacy test with some factors that we believed could be influential in decision making, such as mood, risk-taking and gambling experience.

Block 2 contained the 10 rounds of roulette and therefore the most vital part of the survey, the experiment. After being assigned one of four treatments, which are presented in 3.2.3., the participant began playing the roulette game. Regardless of treatment, each participant was prompted with the same bet and outcome during each round to maintain consistency. During each round, a participant was asked to either play a given bet (to bet on black for example) or skip the bet. If they chose to play the bet, they were asked to answer how confident they were of winning on a 1 to 7 Likert scale. After answering this question, participants were told which number the ball landed in and whether they won. If participants instead chose to skip the bet, they were taken to the next round at no cost. Respondents that are subject to a treatment are provided risk information together with the bet. The respondents were incentivized to gamble efficiently through the implementation of an account balance system of fake currency, which would become smaller or larger depending on if they won or lost. Participants were able to see their balance before each bet. This account balance was implemented in order to grant some assurance that respondents were playing to win, by looking to maximize their balance, instead of simply playing to complete the survey. In order to further this behavior, we tied together a donation to charity (Save the Children) with a respondent's final account balance. If the respondent received a higher final balance we would donate more to charity, with the total range spanning from 2 to 5 SEK. If respondents ran out of FakeBucks before the 10 rounds were completed, they were eliminated from the rest of the survey. This was an unfortunate consequence caused by limitations in the Qualtrics survey program, and was deemed to be the best solution to this problem among those available.

In block 3, the respondents were presented with their final balance as a result of their decisions in the roulette game as well as the sum that would be donated to charity if they completed the survey. Furthermore, the respondents were asked questions that would serve as a manipulation check. One of them, which was presented to all respondents (regardless of condition) was an open text question asking them to explain their decision-making process when presented with a bet. The second manipulation check was only offered to those who had received risk information and presented several statements on a Likert scale related to the risk information they had just been exposed to. The statements concerned whether they noticed the risk information, if the risk information was helpful and if it influenced their decision making. These questions served to check whether the risk information was being observed and considered by respondents before making their betting decisions, serving as a compliment to the open question. The answers to the Likert-scale statements could also be compared between the different treatment groups in order to see if a certain type of risk information was more helpful and easier to interpret.

The final part of block 3 consisted of four multiple choice questions from the Berlin Numeracy Test (Cokely et al. 2012). These questions were implemented to analyze whether the understanding of numeracy was correlated to gambling behavior and to see whether it could be tied to achieving a higher final balance.

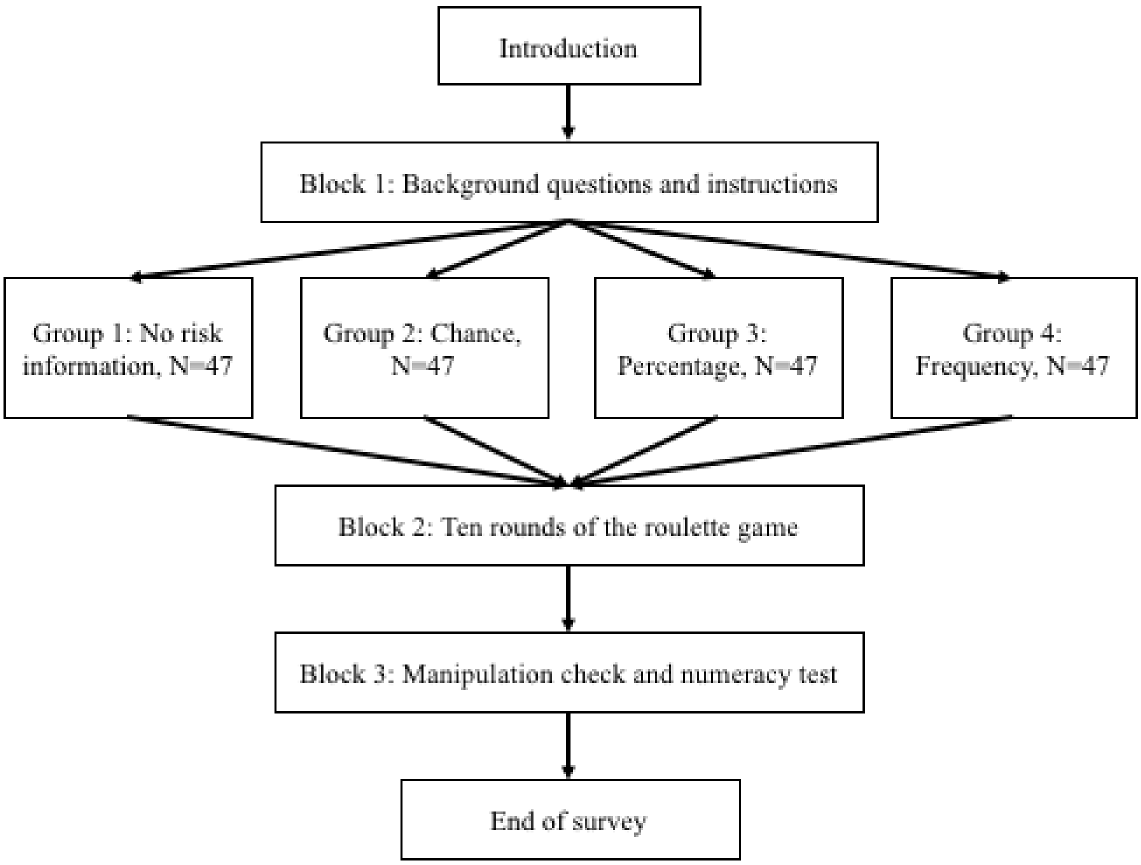


**Figure 1.** Visualization of the survey flow

#### 3.2.3. Risk information

In the study, respondents were randomly assigned to one of four groups before playing, three were provided with risk information, the treatment, and one provided with no risk information, the control group. Participants were allocated into groups by the built-in tool in Qualtrics to ensure an even distribution. The planned treatment method was initially to randomize the risk information shown for each bet to analyze how individuals may act differently depending on the risk information shown. However, we decided to enact treatment groups and a control group as it is more in line with established scientific methods.

If the respondent was part of a treatment group, they were provided with risk information before each bet. The risk information was written in bold to make sure that it was clearly visible to respondents. Below are examples of how the bet and the risk information were presented in the survey:

**Table 2.** Examples of how the risk information is presented in the survey.

| | |
|---|---|
| Group 1 – No risk information | Do you wish to bet on black? (Payout 1:1) |
| Group 2 - Verbal | Do you wish to bet on black? (Payout 1:1) **Chance of winning: Medium** |
| Group 3 - Percentage | Do you wish to bet on black? (Payout 1:1) **Chance of winning: 48,6%** |
| Group 4 - Frequency | Do you wish to bet on black? (Payout 1:1) **Frequence of winning: 486 out of 1000 spins** |

Verbal risk information was written as a range from very low to very high and was chosen because it provides players with a vague descriptor of the possibility of winning, giving them a pointer to the risk of the situation but not an accurate estimation. This type of risk information is not entirely dissimilar to the types of rarities typically seen with “loot boxes” popular in games where items with low probability of receiving are described as rare, epic or legendary items.

Percentage was used as it is one of the traditional methods of displaying probabilities. Frequency was chosen for a similar reason and is according to research more easily understood correctly when it comes to probabilities than percentages as presented in the theoretical framework.

Other types of risk information in contention for a place in the study were expected value and odds, and their usefulness could potentially be evaluated in future studies. These types of risk information were not included in the study due to concerns that they would not be properly understood by participants compared to the types used.

### 3.2.4. Expected value of the roulette game

The roulette game that was presented in the survey consisted of 10 rounds, of which 4 were winning bets. As participants started with a balance of 500 FakeBucks and each win resulted in +100 FakeBucks, the highest final balance a participant could achieve was 900 FakeBucks providing that the participant skipped all losing bets and played every winning bet. The expected final balance of playing where a participant would blindly guess between skipping and playing is $500 + 0.5 \times -100 \times 6 + 0.5 \times 100 \times 4 = 400$ FakeBucks, a loss of 100 FakeBucks. The expected value of playing will serve as a benchmark and will be compared to the results of the study.

### 3.2.5. Independent and dependent variables

The main independent variable of the research study is the treatment, i.e. which type of risk information the participant received. Numeracy, complexity of decision making and gambling experience also served as independent variables used to compare respondents' decision making and were used for hypothesis testing and explorative analyses. Numeracy was measured through the Berlin Numeracy Test, consisting of four multiple choice questions. Respondents were then divided into two groups based on the number of correct answers. Those with 0 to 2 correct answers were declared as having low numeracy while those having 3 to 4 correct answers were declared as having high numeracy. Complexity of decision making was derived from the open form question asking participants to explain their decision making progress. Answers were categorized on a scale from 1 to 5 where a low score meant that little thought went into their decision making and a high score meant that the participant gave a lot of thought into when (and when not) to bet. Participants were then divided into groups of low (1-3) and high (4-5) complexity. Participants who provided illegible answers were assigned low complexity. A similar grouping was made with gambling experience with respondents being divided into a non-gambling group (never or sporadically gambling) and a gambling group (gambling once a month or more). These groupings were performed in order to create larger groups, allowing for more robust statistical tests.

The key dependent variable of the survey that serves as an aggregator for good decision making is the final balance in the roulette game. It can show, on a general level, whether an individual made wise or unwise betting decisions and whether they tended to play winning or losing bets. However, there are some faults with using the final balance as a measure of good decision making, which is further explained in the discussion part of the study. Another dependent variable to provide better insight into decision making was the proportion of respondents who played during each round. Together with an independent variable, the data can be structured to analyze if a condition caused a higher or lower proportion of respondents to bet during certain rounds. In order to compare which risk information respondents liked the best, four statements regarding noticeability, helpfulness, effect on decision making and effect on informed decision making were used. These were measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Confidence of each bet, the final dependent variable, was measured using the same scale.

## 3.3. Data analysis

### 3.3.1. Dropout analysis

In total, there were 252 responses to the Qualtrics survey but only 188 completed the ten rounds of the roulette game. This means that 64 respondents chose to exit the survey before taking part in the most important part of the survey. In fact, 20.2% of participants left the survey before one minute had passed. 21 respondents did continue past the first question of the survey asking them to provide consent in regards to GDPR. A further 28 exited the survey before answering the knowledge check question. 4 respondents answered the knowledge check question incorrectly twice and were excluded from the analysis. The large number of dropouts could be explained by the lengthy welcome, GDPR information and rule overview screens.

### 3.3.2. Tools for analysis

The data collected from the Qualtrics survey was exported to SPSS for testing and analysis. To get a better understanding of the data, descriptive data was collected and summarized to receive an overview of the sample and their performance in the roulette game. A one-way ANOVA test was performed to test the effect of risk information on final balance followed up by a Tukey post-hoc test in order to identify where significant differences existed. Similar tests were conducted testing the proportion of players who chose to bet across every condition, investigating if certain groups were more likely to play specific bets. This was complemented by additional tests where bets of the same probability to win were grouped together. To investigate whether different types of risk information were rated differently, a one-way ANOVA test was performed.

Subsequently, the hypothesis testing was performed. For hypothesis 1, shortened as H1, a one-way ANOVA test was performed to compare the means of confidence between different conditions. For H2, a Kruskal-Wallis H test was performed to compare mean ranks between low and high numeracy. A non-parametric test was chosen as the introduction of another independent variables led to smaller groups, for which non-parametric tests are stronger. For H3, one sided t-tests were performed against the probability of the underlying bet being tested. Finally, the additional findings were the products of t-tests and Kruskal-Wallis H tests in order to find significant differences between groups. For all tests, a significance level of five percent has been used as it is the highest significance level that is scientifically acceptable (Bryman, Bell, & Harley, 2018).

## 3.4. Critical review of the research method

The choice of employing a survey when investigating how risk information can affect decision making was motivated by the desire to create an experimental environment that would be viable in a society affected by covid-19. It is possible that taking betting decisions in the guise of a survey is too dissimilar from the experience of taking betting decisions in a real-life scenario, where the stakes are real. While an experiment of this nature does not necessarily mean having participants use real money, there are likely other cues and prompts that are present in real betting scenarios, whether they are digital or physical, that this survey has failed to replicate. It is therefore possible that the results of the study cannot be translated into decision making in actual gambling scenarios. This disparity could be lessened by performing the experiment in a non-survey environment, for example a custom-designed website, where the implementation of visual and audio cues could be implemented. This would likely require more time and resources than the authors were able to spend. In a similar way, the decision making context of playing roulette might be different enough from other betting scenarios that the conclusions of the study cannot carry over to other games of chance. As the purpose of the study was to help the general public, choosing the most popular gambling format amongst the public could have led to more relevant and useful findings. Additionally, the structure of the roulette game was chosen at random and there was no real thought process behind having winning bets during certain rounds of the game. By randomizing which bet would be winning or losing the authors wanted to capture the feeling of randomness that is tied to games of chance, but in the future it may be worthwhile structuring the game according to guidelines.

As the survey was spread through social media, the respondents make up a convenience sample which is not representative of the Swedish population. This is made apparent by the skewed gender distribution of the respondents, with a sizable majority being men (63.6%). This could be a sign of a potential sampling bias, where segments of the population are either not represented enough or at all, which could mean that the results of the study would fail to replicate with a different sample. While men gamble to a greater extent than women (Spelinspektionen, 2018), the purpose of this study was to reach the general population not gamblers in particular.  In order to create a better understanding of the sample, more background questions should have been implemented, such as education. This could have granted other independent variables that might affect decision making when betting. In addition to a sample that is not representative, questions can be raised regarding the relatively small amount of respondents with conditions containing less than 50 participants each. In an effort to account for small groups, non-parametric tests have been employed when suitable.

## 3.5. Reliability and validity

The reliability of a study indicates whether the results are able to be replicated if performed in a similar manner (Bryman, Bell, & Harley, 2018). Reliability could prove difficult to uphold due to the nature of gambling in general and the structure of the survey. As many respondents motivated their decision making with "gut feeling" and "playing when it felt right", or even playing randomly, it remains unsure whether a survey with the same structure would generate the same results. The Cronbach Alpha, a measure of internal reliability, of respondents' betting behavior over the ten rounds of the roulette game was 0.652. As a reference point, the minimum for efficient internal reliability is set at 0.7 (Bryman, Bell, & Harley, 2018). A low Cronbach's Alpha could indicate structure and order of the betting rounds being influential, as respondents may have made certain decisions due previous results in the game. This could hurt the reliability of looking at respondent decision making as an aggregate score, for example via the final balance. This also means that the structure of the roulette game can have a direct impact on the result, which should have been considered to a greater extent before the structure was decided. This could also mean that similar future research needs to adhere to the same widely accepted format in order to maintain reliability, similar to the Berlin Numeracy Test.

The validity of a study indicates whether a study is measuring what it was designed to measure (Bryman, Bell, & Harley, 2018). Internal validity concerns whether a treatment explains the respondents' behavior in an experiment (Söderlund, 2010). To further internal validity, participants were randomly allocated into the different condition groups via Qualtrics. To ensure that respondents noticed the risk information that was presented before them, questions serving as manipulation checks were present in the survey. One of these questions concerned whether respondents noticed the risk information they were exposed to. The results of this question can be found in table 5. External validity concerns whether the results of the experiment can be applied on general level, and in other situations (Söderlund, 2010). A hindrance to the external validity of the survey is the fact that it is based on a convenience sample, which is likely not representative of the whole population. Additionally, the choice of a roulette game could hurt the validity of the study as its results may not carry over to other games of hazard.

# 4. Empirical results

## 4.1. Descriptive statistics

### 4.1.1. General background descriptives

The Qualtrics survey amassed a total of 252 responses. Out of these responses, 4 were disqualified due to answering the knowledge check question incorrectly in their two attempts. A further 4 ran out of FakeBucks during the roulette game which eliminated them from the latter parts of the study. The mean average age of respondents was 32 years, and the sample was overrepresented by men (63.6%) compared to women (36.4%). As age and gender were optional questions, they represented slightly smaller samples, with 187 and 181 observations, respectively.

The current mood of participants was generally good, with 55.1% and 13.4% having somewhat good and extremely good moods, respectively. Out of 187 answers, only one respondent was in an extremely bad mood. In terms of gambling behavior, the sample was characterized by non-gamblers with 34.8% having played no games of chance during the last year while 42.2% only played sporadically during the same time frame. In terms of risk taking, the responses were more varied. Out of 187 respondents, 3.2% strongly disagreed with often taking risks, while 11.8% disagreed and 20.3% somewhat disagreed. As 12.8% of respondents neither agreed or disagreed with being a risk taker, the majority (51.9%) of the sample were risk takers with 34.8% somewhat agreeing to being risk takers and 13.9% agreeing.

### 4.1.2. Roulette game statistics

Out of 252 total responses, 188 participated in the roulette game that was central to the study. The average final balance of those who participated in the roulette game was 542.55 FakeBucks, which is higher than the starting balance of 500 FakeBucks and higher than the expected value of 400 FakeBucks. 4 respondents exited the game early by being reduced to a balance of 0 FakeBucks before completing ten rounds. The most common final balance was 500 FakeBucks (32.4%) followed by 600 FakeBucks (23.4%), 700 FakeBucks (15.4%) and 400 FakeBucks (10.6%). 5 respondents achieved the highest possible final balance of 900 FakeBucks.

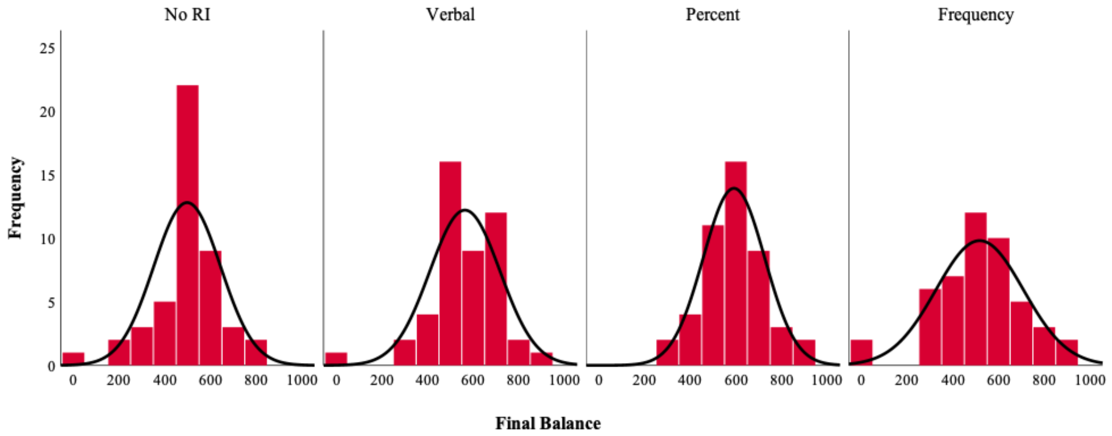


**Figure 2.** Histogram showing frequency of final balance in the four groups

The histogram shows that the distribution is more skewed to the right for those that received risk information, most notably those who were exposed to percentages, which means that the average final balance was higher compared to other groups. It can also be observed that the distribution is the flattest for those who were exposed to frequencies, meaning that there was a high variance in results.

## 4.2. Risk information and decision making

In order to answer whether risk information had an effect on decision making, a one-way between subjects ANOVA was conducted to compare the effect of risk information on the final balance in an environment without and with the three different types of risk information. Presenting risk information had a significant effect on final balance at the $p<.05$ level [$F(3, 184) = 3.44$, $p=0.018$]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for those who received risk information via percent (M=591.49, SD=134.86) was significantly different than the score for those who received no risk information (M=497.87, SD=146.69). However, the score for the other types of risk information, verbal (M=563.83, SD=153.83) and frequency (M=517.02, SD=191.47) did not differ significantly from the score of those who received no risk information. This means that providing information in percent that pertains to risk before a betting decision will increase the likelihood that the player, generally, plays more favorable bets and fewer unfavorable bets as compared to providing no risk information.

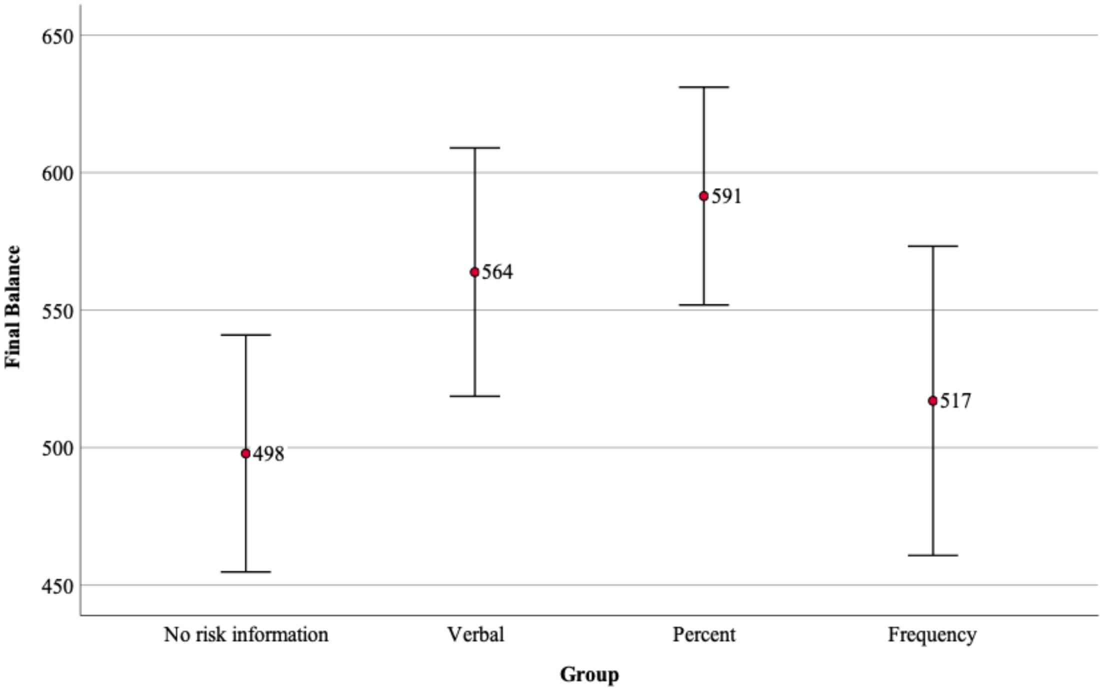


**Figure 3.** Mean final balance, error bars showing a 95% confidence interval

The error bars provide a visualization of the mean final balances across conditions. As can be observed, those who received no risk information or frequencies seemed to perform worse than those with verbal or percentage-based risk information. The only significant difference could be found between the leader, percent, and the loser, no risk information. The mean final balance in all groups is higher than the expected value of 400 FakeBucks, which means that the participants, on average, performed better than someone who randomly played or skipped each bet.

**Table 3.** Mean tendency of respondents to bet across the four conditions

| | No RI | Verbal | Percent | Frequency |
|---|---|---|---|---|
| Mean | 0.57 | 0.63 | 0.65 | 0.62 |
| Min | 0.00 | 0.00 | 0.00 | 0.30 |
| Max | 1.00 | 1.00 | 1.00 | 1.00 |

No significant difference between playing and skipping bets could be found across the four conditions. It can be observed that no respondents in the frequency condition skipped all bets, whereas this occurred in the other conditions. This will have resulted in a higher variance in results for the frequency condition, as the other conditions had respondents who scored 500 in final balance due to skipping every bet. However, since only 4 respondents in total skipped all bets (2 in no RI, 1 each in verbal and percent) this effect is minimal. In general, the tendency to play did not vary much between conditions. However, as there are sizable differences in final balances across conditions there must exist differences in which bets participants tended to play.

**Table 4.** Proportions of respondents who bet across the four conditions

| | P. of winning | No RI n=47 | Verbal n=47 | Percentage n=47 | Frequency n=47 | Total n=188 |
|---|---|---|---|---|---|---|
| Round 1 | 48.6% | 0.70 | 0.81 | 0.62 | 0.70 | 0.71 |
| Round 2 | 32.4% | 0.47 | 0.34 | 0.38 | 0.53 | 0.43 |
| Round 3 | 2.7% | 0.13 | 0.19 | 0.19 | 0.19 | 0.18 |
| Round 4 | 48.6% | 0.70 | 0.85 | $0.94_{a,b}$ | $0.72_{b}$ | 0.80 |
| Round 5 | 32.4% | 0.62 | 0.54 | 0.55 | 0.53 | 0.56 |
| Round 6 | 2.7% | 0.28 | 0.17 | 0.26 | 0.34 | 0.26 |
| Round 7 | 64.9% | $0.70_{a,c}$ | $0.98_{c,d}$ | $0.98_{a,b}$ | $0.78_{b,d}$ | 0.86 |
| Round 8 | 48.6% | 0.64 | 0.75 | 0.80 | 0.63 | 0.71 |
| Round 9 | 97.3% | 0.80 | 0.91 | 0.94 | 0.91 | 0.89 |
| Round 10 | 64.9% | 0.63 | 0.84 | $0.89_{a}$ | 0.82 | 0.79 |

*Note*: Proportions in the same row that share subscripts differ at $p<0.05$. Proportions without subscripts do not differ at a significant level.

The table shows the proportion of respondents in each condition who chose to play a specific round, where 1 equals to every participant playing and 0 equals to no participant playing. There are statistically significant differences in proportions of round 4, 7 and 10, where those who were subjected to risk information in percent (or verbal in round 7) were more likely to play than those who received no risk information or frequencies. The higher proportions of respondents who betted during round 4, 7 and 10 in the percent and verbal conditions help explain why these groups scored higher on a mean level. The implications of these differences can be found in the discussion.

Inspecting the table, it seems that the proportion of people who played is larger than the probability to win in almost all cases, meaning that respondents are more risk taking than they ought to be despite being presented with the probability of winning. During round 9, however, where respondents were presented with a very high probability bet, the proportion of respondents who bet was lower than the probability to win. Further statistics on the proportions of respondents who bet across the four conditions, grouped after the probability of bets, can be found in the appendix (table 13). The table reveals that those who received risk information in percentages or verbally were significantly more likely to play bets with a high (64.9%) probability of winning compared to other conditions.

## 4.3. Which type of risk information was regarded most favorably?

**Table 5.** ANOVA of risk information grades measured on a 1-7 Likert scale

| | Verbal | Percentage | Frequency |
|---|---|---|---|

| | n=40 | | n=42 | | n=42 | |
|---|---|---|---|---|---|---|
| | μ | σ | μ | σ | μ | σ |
| Noticeability | 5.73 | 1.75 | 6.23 | 1.16 | 5.79 | 1.49 |
| Helpfulness | 5.38 | 1.58 | 5.95 | 1.25 | 5.65 | 1.31 |
| Influenced decisions | 5.00 | 1.92 | 5.71 | 1.58 | 5.35 | 1.48 |
| Informed decisions | 4.98 | 1.82 | 5.60 | 1.59 | 5.40 | 1.28 |
| Overall score (Cronbach's alpha = 0.911) | 5.27 | 1.58 | 5.88 | 1.28 | 5.55 | 1.20 |

No significant difference could be found between treatments in any of the statements or as an overall score. However, the mean score in all aspects was the highest for those who received risk information via percent, while verbal scored the lowest in all aspects. In general, it seems like respondents noticed the risk information which points to that they were aware of the manipulation.

## 4.4. Hypothesis testing

**H1**

**Table 6.** ANOVA of confidence, measured on a 1-7 Likert scale, over each round across four conditions

| No RI | Verbal | | Percentage | | Frequency | | | |
|---|---|---|---|---|---|---|---|---|
| | n=47 | | n=47 | | n=47 | | n=47 | |
| | μ | σ | μ | σ | μ | σ | μ | σ |
| R1 | 4.45 | 0.79 | 4.39 | 0.89 | 4.34 | 1.37 | 4.33 | 1.05 |
| R2 | 3.82 | 1.18 | 3.50 | 1.41 | 3.83 | 1.54 | 4.20 | 1.15 |
| R3 | 2.33 | 1.75 | 2.88 | 2.20 | 2.00 | 1.32 | 2.30 | 1.77 |
| R4 | 4.27 | 0.94 | 4.49 | 1.17 | 4.50 | 1.45 | 4.59 | 1.18 |
| R5 | 3.90 | 1.26 | 3.88 | 1.51 | 3.62 | 1.55 | 3.80 | 1.19 |
| R6 | 2.62 | 2.10 | 4.13 | 2.42 | 3.08 | 1.62 | 3.25 | 1.65 |
| R7 | 4.91 | 0.96 | 5.21 | 1.01 | 5.00 | 1.37 | 5.19 | 1.14 |
| R8 | 4.47 | 1.17 | 4.55 | 1.12 | 4.43 | 1.52 | 4.69 | 1.00 |
| R9 | 6.00 | 1.15 | 6.36 | 0.84 | 6.05 | 1.13 | 6.05 | 1.01 |
| R10 | 5.24 | 1.02 | 5.44 | 1.00 | 5.00 | 1.36 | 5.11 | 1.66 |

No significant difference could be found between means in any of the rounds over the four conditions. The hypothesis can therefore not be empirically supported by this study's findings.

**H2**

In order to determine whether low numeracy led to higher risk aversion a Kruskal-Wallis test was performed to compare the tendency of playing between players with high (3-4 points) and low (0-2 points) numeracy over the four conditions. No significant difference could be found in risk aversion between players subjected to no risk information, percent and frequency. For those that received verbal risk information, players with low numeracy were more likely to play during round 2 and 8 at a significance level of $p<0.05$ (see appendix, Table 14). This means that those who scored lower on the numeracy test were less risk averse during these two rounds on a significant level. However, since this tendency could not be shown over more rounds and over other conditions, the hypothesis cannot be supported.

**H3**

In order to investigate whether respondents are more risk seeking when presented with low-probability gains, and risk averse when presented with high-probability gains, several one-sided t-tests were performed. In a "perfect world", where individuals bet according to probability, the average tendency to play a bet would correspond to its probability of winning.

For low probability gains, the null hypothesis is that the mean proportion of playing is equal to or lower than the probability of winning across all conditions. The alternative hypothesis is that the mean proportion is higher than the probability of winning across all conditions.

For bets with 32.4% probability of winning (round 2 and 5), participants played more often than expected at a significant level $p<0.05$ across all types of risk information – the null hypothesis can be rejected.

For bets with 2.7% probability of winning (round 3 and 6), participants played more often than expected at a significant level $p<0.05$ across all types of risk information – the null hypothesis can be rejected.

For high probability gains, the null hypothesis is that the mean proportion of playing is equal to or higher than the probability of winning. The alternative hypothesis is that the mean proportion of playing is lower than the probability of winning.

For bets with 64.9% probability of winning (round 7 and 10), those who received risk information played more often than expected at a significant level $p<0.05$, but not those who received no risk information – the null hypothesis cannot be rejected.

For the bet with 97.3% probability of winning (round 9), those who received no risk information played less often than expected at a significant level $p<0.05$, but not for those who received risk information– the null hypothesis cannot be rejected.

To summarize, the t-tests show that participants were risk seeking when presented with low probability gains, being more likely to play than the probability of winning on a significant level. In terms of risk-averseness when presented with high probability gains, the results were mixed. When the bet presented had a very high probability of winning (97.3%), participants played less than they should in a "perfect world". For the bets with high probability of winning (64.9%) those with no risk information were not significantly more likely to play, while participants in the other conditions were.

**Table 7.** Summary of hypothesis testing

| | | |
|---|---|---|
| H1 | Participants will be more confident in their bets when risk is presented in frequencies rather than percentages. | Not supported |
| H2 | Participants low in numeracy will be more risk averse. | Not supported |
| H3a | Participants will be risk seeking when presented with low probability gains. | Supported |
| H3b | Participants will be risk averse when presented with high probability gains. | Not supported |

## 4.5. Additional findings

### 4.5.1. Numeracy and final balance

**Table 8.** Kruskal-Wallis H test on final balance across conditions and numeracy

| | N | Mean Rank |
|---|---|---|
| No RI, low numeracy | 24 | 69.33 |
| No RI, high numeracy | 27 | 82.67 |
| Verbal, low numeracy* | 18 | 86.61 |
| Verbal, high numeracy* | 27 | 117.46 |
| Percent, low numeracy | 20 | 100.28 |
| Percent, high numeracy | 26 | 106.38 |
| Frequency, low numeracy* | 25 | 68.30 |
| Frequency, high numeracy* | 18 | 116.64 |
| Total | 185 | |

*=significant difference found within condition at $p<0.05$

Of the 188 who participated in the roulette game, 185 answered the four questions presented at the end of the survey known as the Berlin Numeracy Test, which is a widely accepted test for measuring numeracy skills consisting of four multiple-choice questions. The mean test score for this sample of respondents was 2.29. 14 respondents (7.6%) answered incorrectly on all questions and 29 respondents (15.7%) got all questions right. The most common outcome, achieved by 53 respondents (28.6%), was answering three questions correctly. The easiest question (Q1) was answered correctly by 126 respondents (68.1%), while the most difficult question (Q4) was only answered correctly by 67 respondents (36.2%).

An independent-samples t-test was conducted to compare the effect of numeracy score on final balance in low and high numeracy conditions. There was a significant difference in the final balance of low numeracy (n=87, M=511.49, SD=119.52) and high numeracy (n=82, M=607.32, SD=148.89); $t(167)=-4.63, p<0.001$. This indicates that those with high numeracy performed better in the roulette game, taking more winning bets and fewer losing bets on average.

A Kruskal-Wallis H test showed that there was a statistically significant difference in final balance between the different groups of risk information and numeracy, $\chi 2(7) = 23.621$, $p = 0.01$. A further Kruskal-Wallis H performed between numeracy groups in each condition showed that there was a statistically significant difference in final balance between low and high scorers in numeracy for the verbal, $\chi 2(1) = 4.557$, $p = 0.033$, and frequency, $\chi 2(1) = 7.553$, $p = 0.006$, conditions. Together, this indicates that respondents subjected to no risk information or percent were less influenced by their numeracy skills compared to the verbal and frequency conditions. This indicates that risk information presented in these types are less likely to be understood correctly by those with poor numeracy skills.

### 4.5.2. Gambling experience: observed effects on final balance and numeracy

In order to investigate whether gambling experience had a significant effect on final balance in the roulette game, a Kruskal-Wallis H test was performed between non-gamblers (those who gamble sporadically or not at all) and gamblers (those who gamble monthly, weekly or daily). The test showed that there was no significant difference in final balance between the groups, $\chi 2(1) = 1.524$, $p = 0.217$, with a mean rank final balance of 91.49 for non-gamblers and 102.71 for gamblers (see appendix, table 11). No significant differences could be found within conditions, either.

Intuition might suggest that people with plenty of gambling experience would end up with a bigger final balance due to their experience in similar situations. However, as Newall et al (2020) remarks, gamblers may be more focused on their short-term losses and gains and will not account for the fact that the house always wins in the end. In order to test whether gamblers were more proficient in numeracy, perhaps due to their exposure to games of hazard, a Kruskal-Wallis H test was conducted to compare numeracy scores for non-gamblers and gamblers. There was not a significant difference between the groups, $\chi 2(1) = 0.926$, $p = 0.336$, with a mean rank of 83.07 for non-gamblers and 91.42 for gamblers (see appendix, table 12). However, it should be noted that the sample for gamblers who answered numeracy questions is significantly smaller (n=39) than the sample of non-gamblers (n=130), meaning that more conclusive data could be found provided the data population included more gamblers.

#### 4.5.3. Complexity

**Table 9.** Proportions of respondents who bet across the four conditions and two complexity scores

| | P. of winning | No RI | | Verbal | | Percentage | | Frequency | |
|---|---|---|---|---|---|---|---|---|---|
| | | Low | High | Low | High | Low | High | Low | High |
| | | n=29 | n=18 | n=20 | n=28 | n=26 | n=21 | n=29 | n=17 |
| R1 | 48.6% | 0.66 | 0.78 | 0.85 | 0.75 | 0.58 | 0.71 | 0.72 | 0.65 |
| R2 | 32.4% | 0.48 | 0.44 | 0.35 | 0.32 | 0.39 | 0.38 | 0.59 | 0.47 |
| R3* | 2.7% | $0.21_a$ | $0.00_a$ | $0.35_b$ | $0.07_b$ | $0.35_c$ | $0.05_c$ | $0.31_d$ | $0.00_d$ |
| R4 | 48.6% | 0.66 | 0.78 | 0.90 | 0.82 | 0.89 | 0.95 | 0.69 | 0.82 |
| R5 | 32.4% | 0.66 | 0.56 | 0.68 | 0.43 | 0.62 | 0.48 | 0.55 | 0.53 |
| R6* | 2.7% | $0.38_a$ | $0.11_a$ | $0.37_b$ | $0.07_b$ | $0.35_c$ | $0.10_c$ | $0.55_d$ | $0.00_d$ |
| R7 | 64.9% | 0.72 | 0.67 | 1.00 | 0.96 | 0.96 | 1.00 | 0.71 | 0.88 |
| R8 | 48.6% | 0.62 | 0.67 | 0.82 | 0.71 | 0.76 | 0.86 | 0.64 | 0.59 |
| R9 | 97.3% | 0.75 | 0.89 | 0.94 | 0.89 | 0.92 | 0.95 | 0.89 | 0.94 |
| R10* | 64.9% | 0.57 | 0.72 | 0.77 | 0.86 | 0.88 | 0.95 | 0.81 | 0.82 |

*Note*: Proportions in the same row that share subscripts differ at p<0.05. Proportions without subscripts differ at p>0.05. *=significant differences found within the row.

In order to investigate whether the proportions were different from each other within conditions, several Kruskal-Wallis H tests were performed. The significant differences could be found during round 3 and 6, the rounds with the lowest probability bets. This indicates that those high in complexity generally tend to not play bets which have extremely low chance of winning, regardless of risk information.

Further tests were made in order to investigate whether those with high complexity in decision making ended up with higher final balances. Significant differences were found within the No RI, verbal and frequency conditions at p<0.05 (see appendix, table 15). This indicates that those with higher complexity in explaining their decision making were generally more likely to end up with a higher final budget across these conditions. As this was not the case for those exposed to percentages, this could indicate that percentages are more helpful in fostering good decision making compared to the other forms of risk information. Additionally, No RI and Frequency conditions had the fewest high complexity respondents which could result in these groups performing worse generally in the experiment.

#### 4.5.4. The dream of jackpot

In order to investigate whether the respondents gambled due to the dream of jackpot, the mood benefits it can give and the chance of winning (Binde, 2013), the answers to the open-form question were analyzed. The 139 valid responses were put into four different categories (see table 9) and as we can see most respondents followed a rule of thumb by e.g. only betting on low risk bets or taking expected value into consideration. However, there were 8 who favored the mood benefits that gambling gave and 18 who took a gamble in order to get high rewards. Thus, some of the respondent's answers are conforming as to why people gamble according to Binde (2013). It is possible that the respondents that did not gamble due to the dream of jackpot or the mood benefits gambled due to intellectual challenges or social rewards. As the open-form question did not present the opportunity to disclose this information as it asked them to explain their decision-making process, not why they chose to gamble, these responses were not adequately captured.

**Table 10.** Open-form questions

| Categories | Examples of answers | Number of respondents |
|---|---|---|
| Respondents who gamble randomly | "I played every other bet" | 28 |
| Respondents who gamble almost everything for fun | "I played almost all bets for fun" | 8 |
| Respondents who deviate from their rule of thumb due to the chance of getting a high reward | "Played some risky bets to get big wins but it didn't happen" | 18 |
| Respondents that follow a rule of thumb | "Only played those with more than 50% chance of winning" | 85 |

## 4.6. Summary of results

- Risk information in percentage will generally increase the likelihood that a player plays more winning bets and fewer losing bets compared to when presented with no risk information.
- In terms of noticeability, helpfulness, influence on decisions, and informed decisions, there were no significant difference between the three treatments.
- Participants were not more confident in their bets when presented with frequency rather than percentage.
- Low numeracy did not lead to higher risk aversion.
- Participants were risk seeking when presented with low probability gains.
- When participants were presented with high probability gains, there was no clear risk aversion.

- People high in numeracy performed better in the roulette game.
- People low in numeracy may not understand verbal and frequency risk information properly.
- Gamblers did not perform better than non-gamblers in the roulette game. Neither did they score higher on the numeracy test.
- People who have more complex thought processes behind their betting decisions tend to skip bets with extremely low chance of winning, regardless of risk information.
- Some respondents show tendencies of playing for mood benefits or chasing the jackpot.
- Additionally, those with more complex thought processes were also more likely to have a high final balance.

# 5. Discussion and conclusion

To answer the research question, those that receive risk information were in general more likely to end up with a higher final balance in the roulette game. These differences were due to a higher tendency to play during bets which were likely to win, and a lower tendency to play bets that were unlikely to win. In that regard, it seems like those who receive risk information, especially in percentages, are more likely to win and less likely to lose when playing. However, this does not necessarily mean that they make better, more informed decisions, but it could point to that they collectively were more likely to play winning bets. The study has managed to identify other factors that could lead to more effective playing, namely numeracy and complexity in decision making.

## 5.1. Risk information – winning more and losing less

The research question posed earlier in this study concerned whether "Does the introduction of risk information reduce the chance of losing?". The results of the survey show that those that receive risk information via percent tended to end up with a higher final balance and have therefore played the roulette game better. However, this was caused by their increase likelihood of playing winning bets, particularly those with a high probability of winning, and not from a tendency to play less losing bets. The authors expected that participants who knew exactly how low the chance of winning was would refrain from taking these bets. Applying the theoretical framework introduced earlier, potential explanations to this can be found. From the empirical support found for H3a, there is evidence for that participants tended to display risk-seeking behavior when presented with low-probability gains. (Kahneman & Tversky, 1979). While one could assume that this decision making stems from biases or a flawed decision making system, Binde has a different perspective. According to Binde, this risk-seeking behavior can be explained by how humans dream of the big jackpot and look for the potential mood benefits of winning an unlikely bet (Binde, 2013). Providing risk information did not seem to reduce this behavior, which could coincide with the theory that these risky bets are not played because of a misunderstanding of the probability of winning, but due to human motivations. As people tend to rank casino sites with high risk better (Konietzny, 2017), it seems like there exists an intrinsic human drive behind playing risky bets.

While those who received risk information were not less likely to play losing bets, they still ended up with higher final balances. What is this caused by? From the results of the study, it was shown that people who received risk information, particularly percent, were more likely to play winning bets. This increase was partially due to an increased tendency to play high probability bets: particularly round 7 and 10 which had a probability to win of 64.9%. It seems like the introduction of risk information reduced the risk-aversion typically associated with high-probability gains (Kahneman & Tversky, 1979). While no significant difference was found, a similar pattern was found for round 9 (97,3% probability of winning). Risk information might have been influential in this aspect because there is not a similarly strong motivation when faced with high-probability gains as there is with low-probability gains. This asymmetry could also be explained by the fact that there was no real money or risk involved, which caused participants to play at a higher proportion than would be expected in real life scenarios. The other reason why those who received risk information in percent tended to achieve a higher final balance was the significantly higher proportion of participants who tended to play during round 4, which had a 48.6% probability of winning. Despite this relatively mediocre probability of winning, a the proportion of participants who played, for those who received percentages, was 0.95. As round 4 was a winning bet, the risk that almost everyone took paid off. How come these players were more likely to play during this round? One possible explanation is that the previous bet was a very low possibility of winning (2.7%) which meant that betting on red seemed like an obvious choice. For those that received risk information, the sudden change in probabilities might have furthered this effect, as the context in which probabilities are shown can impact how they are perceived (Spiegelhalter, 2019)

Does this mean that the introduction of risk information would lead to more gamblers winning? Not necessarily. Even though those who received risk information were more likely to play high probability bets, their tendency to play still outmatched the underlying probability of winning. If the bets which had a higher probability of winning ended up being losing bets, a more conservative approach may have been better. Therefore, it cannot be said that the percent condition played more perfectly, but that the respondents collectively took risks that paid off. The introduction of risk information is more nuanced than the authors previously believed, as it can even lead to players venturing further away from a “perfect world”, where bets are made based on the underlying probability of winning. In the long run, players that play according to the underlying probability to win will lose less often and win more often, which means that risk information might not bring us closer to this perfect world. Following this logic, it might not be preferable to introduce risk information as it can increase risk seeking behavior in certain scenarios. On the other hand, providing players with more information before a bet is unlikely to be something negative, as it is giving them the opportunity to make a more informed decision. A more informed decision is in this scenario is one that is based on the probability of winning. However, if the probabilities are misinterpreted, as humans are prone of doing (Spiegelhalter, 2019), they could prove to be harmful instead. As such, it is important to study whether participants have the prerequisites to understand and apply the risk information that is provided, which is discussed in 5.3.

## 5.2. The most apt choice of risk information

While there are no statistically significant differences in how different types of risk information are favored by respondents, it is likely that displaying probabilities through percentages or frequencies is preferable, as they convey more information than the verbal type. There could also be ties to numeracy and how well the risk information is interpreted, as numeracy skills were not as influential in terms of achieving a high final balance when exposed to percentages as opposed to frequencies. This could point to percentages being easier to understand in comparison to frequencies in betting contexts than previously believed. In order to fully understand the differences between risk information in percent and frequency in betting scenarios further research must be made. The underperformance of the frequency format could be explained by the apparent importance of numeracy, as numeracy skills had a significant impact on the final balance of those who received risk information through frequencies. Perhaps frequency would have also been easier for participants to understand if paired with visualization as Andersson and Almqvist (2016) suggested.

## 5.3. Other factors explaining high performance in the roulette game

The additional findings could indicate an area for improving betting decision making without involving risk information.. While there was no support for that those with low numeracy were less risk averse (Millroth, Nilsson, & Juslin, 2019), those with high numeracy outperformed those with low numeracy in the verbal and frequency conditions. This could implicate that these types of risk information require better understanding of probabilities to use effectively. The numeracy of the respondent had strong links to the final balance of the roulette game, and while this might not indicate that they take smarter decisions, it could mean that those who have a better understanding of probabilities are more likely to win and less likely to lose. This could mean that betting environments can implement tests that require players to correctly answer numeracy questions in order to be able to play more or play at all. Alternatively, the requirement of a fundamental understanding of numeracy can be implemented as a sort of “betting license”, similar to what is required to drive a car. While an unrealistic and extreme suggestion, implementing requirements for gambling could reduce problematic gambling. Another suggestion of a possible requirement to gambling could be tests asking players about their decision making when playing, as the complexity of a player’s thought process behind playing a bet was also shown to affect their final balance. As those who play randomly or just for fun tend to perform worse than those that have rules of thumb or more complex strategies, it could be worthwhile educating players about simple strategies to reduce potentially dangerous (or at least unwise) gambling.

While having more gambling experience should lead to a better understanding of probabilities and therefore better performances in the roulette game, evidence of this could not be found in the data. However, this could be due to the small number of gamblers present in the sample.

## 5.4. Limitations and suggestions for future research

To guarantee that the survey was interpreted as realistic there could have been questions in To guarantee that the survey was interpreted as realistic there could have been questions in the end of the survey asking what extent participants thought the survey resembled a real-life scenario. Further, it is possible that people would have bet differently if their real money were at stake. The limitation of not having an actual roulette game with sounds and effects might have affected the result. Therefore, the authors recommend that future studies with more resources and time take this into consideration whilst constructing their game. It is already obligatory for gaming machines in the UK to display return-to-player or the odds of winning. It could therefore be interesting to research whether or not return-to-player or odds of winning is correctly understood by players and if it affects their decision making in order to see what type of risk information helps consumers the most. Additionally, questions that asked whether the survey was good, interesting, easy to understand etc. should have been implemented in order to identify potential sources of error. For example, if participants found the survey to be boring and long-winded, they might have chosen to skip bets in order to complete the survey faster. Such sources of error might have skewed the results in a certain direction, which would have affected the conclusion of the report.

While the purpose of the study was to investigate potential methods of reducing problem gambling, the experiment in itself did not revolve around problem gambling but instead at increasing the amount of correct decision, where a correct decision is not playing a losing, often low-probability bet. While there could be some links to reducing losing bets and less dangerous gambling, it is likely that problem gambling is related to deeper reasons than not understanding the underlying probability of winning. While the study shows that risk information can be useful for increasing the aggregate level of correct decisions, a game that is limited in terms of scope (10 rounds) may lead to luck playing a large role in outcomes. An example is the phenomenon described in 5.1 where participants who were exposed to percent collectively chose to take a risk and play during round 4. In an experiment with more rounds, the overall effect of getting lucky would be less pronounced.

A suggestion for future research in this field is to have a larger and more representative sample. This would produce more robust and reliable findings that could be applied on a larger scale. Additionally, future research should test decision making during other games of chance, as they may present other decision making environments and cues. There is also potential for discussing whether other types of risk information are better at replicating decision making in a perfect world, for example expected value or odds. In order to validate whether risk information has any ties to problem gambling and gambling addicts, research should also be focused to investigate if there are any concrete links between them.

# 6. References


Andersson, P., & Almqvist, G. (2016). *Presentationsformatets betydelse vid kommunikation av risk*. https://www.hhs.se/contentassets/213f8e3cefa54441a26c355160382b6c/kapitel-4-risker-och-riskhantering.pdf

Binde, P. (2009). *Vilka är de mest riskfyllda spelen?* Göteborgs universitet. https://gupea.ub.gu.se/bitstream/2077/26177/1/gupea_2077_26177_1.pdf

Binde, P. (2013). Why people gamble: a model with five motivational dimensions. *International Gambling Studies*, *13*(1), 81–97. https://doi.org/10.1080/14459795.2012.712150

Binde, P. (2019). *Self-reported negative influence of gambling advertising in a Swedish population-based sample*. Ub.gu.se. https://gup.ub.gu.se/publication/268869

Bryman, A., Bell, E., & Harley, B. (2018). *Business Research Methods - Bill Harley, Alan Bryman, Emma Bell - häftad (9780198809876) | Adlibris Bokhandel*. Www.adlibris.com. https://www.adlibris.com/se/bok/business-research-methods-9780198809876?gclid=Cj0KCQjwo-aCBhC-ARIsAAkNQiuO8NFEuTMhSxHal-IRpZY2xQkJ6SRpeoSdde3gZBwWqLMTyyjpk2oaAoh2EALw_wcB

Cokely, E., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring Risk Literacy: The Berlin Numeracy Test. *Judgment and Decision Making*, *7*(1), 25–47. http://journal.sjdm.org/11/11808/jdm11808.pdf

*Fakta om spelbranschen*. (2021). Spelbranschens Riksorganisation. https://sper.se/fakta-om-spelbranschen/

Fellbom, J., & Förberg, M. (2019). *VARNINGSTEXTER I SPELREKLAM*. http://arc.hhs.se/download.aspx?MediumId=4364

Folkhälsomyndigheten. (2018). *The Swedish Longitudinal Gambling Study*. Www.folkhalsomyndigheten.se; Swelogs - The Public Health Agency of Sweden. https://www.folkhalsomyndigheten.se/the-public-health-agency-of-sweden/living-conditions-and-lifestyle/alcohol-narcotics-doping-tobacco-and-gambling/gambling/swelogs/

*Gaming machine payouts: return-to-player*. (n.d.). Www.gamblingcommission.gov.uk; The Gambling Commission. Retrieved April 8, 2021, from https://www.gamblingcommission.gov.uk/for-the-public/Safer-gambling/Consumer-guides/Machines-Fruit-machines-FOBTs/Gaming-machine-payouts-RTP.aspx

Gigerenzer, G. (2003). Simple tools for understanding risks: from innumeracy to insight. *BMJ : British Medical Journal*, *327*(7417), 741–744. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC200816/

*Global Gambling Market Report 2021: COVID-19 Impact and Recovery to 2030 - Changing Consumer Gambling Habits During the Lockdown - ResearchAndMarkets.com*. (2021, February 4). Www.businesswire.com; Business Wire. https://www.businesswire.com/news/home/20210204005928/en/Global-

Gambling-Market-Report-2021-COVID-19-Impact-and-Recovery-to-2030---Changing-Consumer-Gambling-Habits-During-the-Lockdown---ResearchAndMarkets.com

Gross Hulth, M. (2021, March 5). Oro för att hemmastudier ökar risken för spelproblem. *SVT Nyheter*. https://www.svt.se/nyheter/lokalt/uppsala/kbt-terapeuten-hemmastudierna-okar-risken-for-spelberoende

Harrigan, K., Brown, D., & Barton, K. (2017). *Classification of Slot Machines in Ontario*. https://www.greo.ca/Modules/EvidenceCentre/files/Harrigan%20et%20al%20(2017)%20Classification%20of%20slot%20machines%20in%20Ontario.pdf

Hobin, E., Vallance, K., Zuo, F., Stockwell, T., Rosella, L., Simniceanu, A., White, C., & Hammond, D. (2017). Testing the Efficacy of Alcohol Labels with Standard Drink Information and National Drinking Guidelines on Consumers' Ability to Estimate Alcohol Consumption. *Alcohol and Alcoholism*, *53*(1), 3–11. https://doi.org/10.1093/alcalc/agx052

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), 263. https://doi.org/10.2307/1914185

Karlsson, A., & Håkansson, A. (2018). Gambling disorder, increased mortality, suicidality, and associated comorbidity: A longitudinal nationwide register study. *Journal of Behavioral Addictions*, *7*(4), 1091–1099. https://doi.org/10.1556/2006.7.2018.112

Konietzny, J. (2017). No risk, no fun: implications for positioning of online casinos. *International Gambling Studies*, *17*(1), 144–159. https://doi.org/10.1080/14459795.2017.1288754

*Kvinnor och män föredrar olika spel*. (2018, March 28). Www.spelinspektionen.se; Spelinspektionen. https://www.spelinspektionen.se/om-oss/statistik/statistiknytt/kvinnor-och-man-foredrar-olika-spel/

Mackinnon, D. P. (2000). The alcohol warning and adolescents: 5-year effects. *American Journal of Public Health*, *90*(10), 1589–1594. https://doi.org/10.2105/ajph.90.10.1589

Magnus Söderlund. (2010). *Experiment med människor*. Liber.

McDowell, M., & Jacobs, P. (2017). Meta-analysis of the effect of natural frequencies on Bayesian reasoning. *Psychological Bulletin*, *143*(12), 1273–1312. https://doi.org/10.1037/bul0000126

Millroth, P., Nilsson, H., & Juslin, P. (2019, July). *The decision paradoxes motivating Prospect Theory: The prevalence of the paradoxes increases with numerical ability*. Journal.sjdm.org. http://journal.sjdm.org/18/18515/jdm18515.html

Newall, P. W. S., Walasek, L., Hassanniakaler, A., Russell, A. M. T., Ludvig, E. A., & Browne, M. (2020). Statistical risk warnings in gambling. *Behavioural Public Policy*, 1–21. https://doi.org/10.1017/bpp.2020.59

Oppenheimer, D. M., Meyvis, T., & Davidenko, N. (2009). Instructional manipulation checks: Detecting satisficing to increase statistical power. *Journal of Experimental Social Psychology*, *45*(4), 867–872. https://doi.org/10.1016/j.jesp.2009.03.009

R. Camilleri, A., & R. Newell, B. (2009, December 7). *The role of representation in experience-based choice*. Journal.sjdm.org. http://journal.sjdm.org/9713/jdm9713.html

Riksdagsförvaltningen. (2018, June 14). *Spellag (2018:1138) Svensk författningssamling 2018:2018:1138 - Riksdagen*. Www.riksdagen.se. https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/spellag-20181138_sfs-2018-1138

Söderlund, M. (2018). *Experiments In Marketing*. Studentlitteratur AB.

*Spelbolag med spellicens*. (2021, February 1). Www.spelinspektionen.se. https://www.spelinspektionen.se/licensansokan/bolag-med-spellicens/

Spiegelhalter, D. J. (2019). *The art of statistics : how to learn from data*. Basic Books.

Sundali, J., T. A. Croson, R., & H. Safford, A. (2012, November). *The impact of near-miss events on betting behavior: An examination of casino rapid roulette play*. Research Gate. https://www.researchgate.net/publication/269095493_The_impact_of_near-miss_events_on_betting_behavior_An_examination_of_casino_rapid_roulette_play

Svensson, I. (2020, March 9). Spelproblemen kostar samhället 14 miljarder varje år. *SVT Nyheter*. https://www.svt.se/nyheter/lokalt/smaland/spelproblemen-kostar-14-miljarder-varje-ar

Vanepps, E. M., & Roberto, C. A. (2016). *The Influence of Sugar-Sweetened Beverage Warnings: A Randomized Trial of Adolescents' Choices and Beliefs*. Hhs.primo.exlibrisgroup.com. https://hhs.primo.exlibrisgroup.com/discovery/fulldisplay?docid=cdi_pubmedcentral_primary_oai_pubmedcentral_nih_gov_5533079&context=PC&vid=46SSOE_INST:46SSOE_view&lang=en&search_scope=MyInst_and_CI&adaptor=Primo%20Central&tab=Everything&query=any

Weber, P., Binder, K., & Krauss, S. (2018). *Why Can Only 24% Solve Bayesian Reasoning Problems in Natural Frequencies: Frequency Phobia in Spite of Probability Blindness*. Hhs.primo.exlibrisgroup.com. https://hhs.primo.exlibrisgroup.com/discovery/fulldisplay?docid=cdi_doaj_primary_oai_doaj_org_article_50d3f6bd45314bdab5b4bdb1375e8549&context=PC&vid=46SSOE_INST:46SSOE_view&lang=en&search_scope=MyInst_and_CI&adaptor=Primo%20Central&tab=Everything&query=any

# 7. Appendix

**Table 11.** Kruskal-Wallis H test on final balance across conditions and gambling experience

| Gambling Risk<br>Rank | N | Mean |
|---|---|---|
| No RI, non-gambler | 36 | 73.33 |
| No RI, gambler | 12 | 92.21 |
| Verbal, non-gambler | 37 | 96.95 |
| Verbal, gambler | 9 | 129.22 |
| Percent, non-gambler | 39 | 114.54 |
| Percent, gambler | 8 | 93.19 |
| Frequency, non-gambler | 32 | 79.83 |
| Frequency, gambler | 15 | 100.17 |
| Total | 188 | |

**Table 12.** Kruskal Wallis H test on whether gamblers have better numeracy

| <br>Rank | N | Mean |
|---|---|---|
| Non-gamblers | 130 | 83.00 |
| Gamblers | 39 | 91.67 |
| Total | 169 | |

**Table 13.** Proportions of respondents who bet across the four conditions, grouped after probability of bets

| Very low (2.7%) | No RI | Verbal | Percent | Frequency | Total |
|---|---|---|---|---|---|
| Played 0 bets | 0.68 | 0.72 | 0.64 | 0.60 | 0.66 |
| Played 1 bet | 0.23 | 0.19 | 0.28 | 0.25 | 0.24 |
| Played 2 bets | 0.09 | 0.09 | 0.08 | 0.15 | 0.10 |
| Low (32.4%) | No RI | Verbal | Percent | Frequency | Total |
| Played 0 bets | 0.30 | 0.36 | 0.36 | 0.32 | 0.34 |
| Played 1 bet | 0.32 | 0.40 | 0.34 | 0.30 | 0.34 |
| Played 2 bets | 0.38 | 0.23 | 0.30 | 0.38 | 0.32 |
| Medium (48.6%) | No RI | Verbal | Percent | Frequency | Total |
| Played 0 bets | 0.17 | 0.06 | 0.06 | 0.06 | 0.09 |
| Played 1 bet | 0.11 | 0.15 | 0.09 | 0.23 | 0.14 |
| Played 2 bets | 0.23 | 0.17 | 0.30 | 0.30 | 0.25 |
| Played 3 bets | 0.49 | 0.62 | 0.55 | 0.41 | 0.52 |
| High (64.9%) | No RI$_{a,b}$ | Verbal$_{a}$ | Percent$_{b}$ | Frequency | Total |
| Played 0 bets | 0.17 | 0.02 | 0.02 | 0.11 | 0.08 |
| Played 1 bet | 0.34 | 0.14 | 0.11 | 0.22 | 0.20 |
| Played 2 bets | 0.49 | 0.84 | 0.80 | 0.67 | 0.72 |
| Very high (97.3%) | No RI | Verbal | Percent | Frequency | Total |

| | | | | | |
|---|---|---|---|---|---|
| Played 0 bets | 0.20 | 0.09 | 0.07 | 0.09 | 0.11 |
| Played 1 bet | 0.80 | 0.91 | 0.93 | 0.91 | 0.89 |

*Note:* Conditions in the same row that share subscripts have means that differ at p<0.05. Conditions without subscripts do not differ at a significant level.

**Table 14.** Kruskal-Wallis H mean ranks across low-high numeracy and risk information conditions

| Round | Condition, numeracy | N | Mean Rank |
|---|---|---|---|
| R1 | No RI, low numeracy | 24 | 100.73 |
| | No RI, high numeracy | 27 | 89.17 |
| | Verbal, low numeracy | 18 | 109.72 |
| | Verbal, high numeracy | 27 | 92.59 |
| | Percent, low numeracy | 20 | 87.63 |
| | Percent, high numeracy | 26 | 87.98 |
| | Frequency, low numeracy | 25 | 94.10 |
| | Frequency, high numeracy | 18 | 84.03 |
| | Total | 185 | |
| R2 | No RI, low numeracy | 24 | 95.90 |
| | No RI, high numeracy | 27 | 94.61 |
| | Verbal, low numeracy | 18 | $99.75_a$ |
| | Verbal, high numeracy | 27 | $70.63_a$ |
| | Percent, low numeracy | 20 | 95.13 |
| | Percent, high numeracy | 26 | 89.08 |
| | Frequency, low numeracy | 25 | 105.30 |
| | Frequency, high numeracy | 18 | 99.75 |
| | Total | 185 | |
| R3 | No RI, low numeracy | 24 | 95.77 |
| | No RI, high numeracy | 27 | 83.35 |
| | Verbal, low numeracy | 18 | 102.19 |
| | Verbal, high numeracy | 27 | 90.20 |
| | Percent, low numeracy | 20 | 95.00 |
| | Percent, high numeracy | 26 | 94.29 |
| | Frequency, low numeracy | 25 | 102.40 |
| | Frequency, high numeracy | 18 | 81.64 |
| | Total | 185 | |
| R4 | No RI, low numeracy | 24 | 87.50 |
| | No RI, high numeracy | 26 | 82.19 |
| | Verbal, low numeracy | 18 | 105.39 |
| | Verbal, high numeracy | 27 | 90.06 |
| | Percent, low numeracy | 20 | 105.90 |
| | Percent, high numeracy | 26 | 103.42 |
| | Frequency, low numeracy | 25 | 77.38 |
| | Frequency, high numeracy | 18 | 95.17 |
| | Total | 184 | |
| R5 | No RI, low numeracy | 24 | 101.83 |
| | No RI, high numeracy | 26 | 97.12 |
| | Verbal, low numeracy | 18 | 101.83 |
| | Verbal, high numeracy | 27 | 84.80 |

| | | | |
|---|---|---|---|
| | Percent, low numeracy | 20 | 100.30 |
| | Percent, high numeracy | 26 | 79.42 |
| | Frequency, low numeracy | 25 | 95.70 |
| | Frequency, high numeracy | 18 | 81.39 |
| | Total | 184 | |
| R6 | No RI, low numeracy | 24 | 88.17 |
| | No RI, high numeracy | 26 | 100.85 |
| | Verbal, low numeracy | 18 | 84.33 |
| | Verbal, high numeracy | 27 | 82.63 |
| | Percent, low numeracy | 20 | 96.60 |
| | Percent, high numeracy | 26 | 93.77 |
| | Frequency, low numeracy | 25 | 102.12 |
| | Frequency, high numeracy | 18 | 89.44 |
| | Total | 184 | |
| R7 | No RI, low numeracy | 24 | 76.60 |
| | No RI, high numeracy | 24 | 84.15 |
| | Verbal, low numeracy | 18 | 103.00 |
| | Verbal, high numeracy | 27 | 99.65 |
| | Percent, low numeracy | 20 | 103.00 |
| | Percent, high numeracy | 25 | 92.14 |
| | Frequency, low numeracy | 25 | 81.28 |
| | Frequency, high numeracy | 18 | 92.94 |
| | Total | 181 | |
| R8 | No RI, low numeracy | 24 | 87.00 |
| | No RI, high numeracy | 24 | 87.00 |
| | Verbal, low numeracy | 18 | $112.00_a$ |
| | Verbal, high numeracy | 26 | $78.92_a$ |
| | Percent, low numeracy | 20 | 108.00 |
| | Percent, high numeracy | 25 | 91.80 |
| | Frequency, low numeracy | 25 | 91.80 |
| | Frequency, high numeracy | 18 | 72.00 |
| | Total | 180 | |
| R9 | No RI, low numeracy | 24 | 76.75 |
| | No RI, high numeracy | 24 | 91.58 |
| | Verbal, low numeracy | 18 | 99.00 |
| | Verbal, high numeracy | 26 | 85.31 |
| | Percent, low numeracy | 20 | 94.55 |
| | Percent, high numeracy | 23 | 91.26 |
| | Frequency, low numeracy | 25 | 88.32 |
| | Frequency, high numeracy | 18 | 94.06 |
| | Total | 178 | |
| R10 | No RI, low numeracy | 24 | 74.13 |
| | No RI, high numeracy | 24 | 81.54 |
| | Verbal, low numeracy | 18 | 92.67 |
| | Verbal, high numeracy | 26 | 93.81 |
| | Percent, low numeracy | 20 | 98.60 |
| | Percent, high numeracy | 23 | 92.02 |
| | Frequency, low numeracy | 25 | 86.14 |
| | Frequency, high numeracy | 18 | 102.56 |
| | Total | 178 | |

Note: Mean ranks that share a subscript within the same round differ at p<0.05. Mean ranks without a subscript do not differ at a significant level.

**Table 15.** Kruskal-Wallis H test on mean final balance and complexity across conditions

| | N | Mean |
|---|---|---|
| No RI, low complexity | 29 | 65.10 |
| No RI, high complexity | 18 | 99.36 |
| Verbal, low complexity | 20 | 78.70 |
| Verbal, high complexity | 28 | 120.30 |
| Percent, low complexity | 26 | 98.02 |
| Percent, high complexity | 21 | 124.36 |
| Frequency, low complexity | 29 | 67.26 |
| Frequency, high complexity | 17 | 119.79 |
| Total | 188 | |