The Influence of Ambiguity and Uncertainty on Wishful Thinking

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Abstract

People are confronted with situations where they have to make choices and judgments every day. In making decisions, people may have a preference for one option over another, and the wishful thinking effect describes their increased optimism and inflation of the likelihood of that option happening. This phenomena has been illustrated in a variety of different contexts, including sporting events and drawing cards from a deck. Further research into the wishful thinking effect illustrates that the greatest amount of this desirability bias is exhibited in situations where the most uncertainty is present. This study expands upon previous research by including the variable of ambiguity, or "uncertainty about uncertainty". I hypothesized that in situations that were more ambiguous, participants would display a greater amount of wishful thinking. To test this, I manipulated the uncertainty, ambiguity, and desirability of two-color square grids and asked participants to make predictions about which color they believed the computer would choose at random. Contrary to my hypothesis, I found that the greater amount of ambiguity, the less wishful thinking they exhibited, and in conditions where there was no ambiguity, participants exhibited the greatest amount of wishful thinking.

The Influence of Ambiguity and Uncertainty on Wishful Thinking

Ask someone which professional football team is likely to win the upcoming game and they will usually choose their favorite team. A person's presidential election prediction is often based on their preferred candidate. If you forgot your umbrella you may be less likely to assume that it will rain, despite the dismal forecast. One thing that all of these examples have in common is that they involve a preferred outcome. Many of life's most important choices rely on the interpretation of evidence, and inferences of probabilities that are most often unknown. Understanding how factors (e.g., a preference for one outcome over another) influence the types of judgments people make is quite important because while many decisions can be relatively inconsequential (e.g., predicting if it will rain or not), some can have lasting consequences (e.g., deciding to apply for a job based on whether or not the person believes he or she will be hired).

For decades researchers have long investigated an individual's bias towards what is preferred (Bar-Hillel & Budescu, 1995; Budescu & Bruderman, 1995; Krizan & Windschitl, 2007; Marks, 1951). Wishful thinking—or the desirability bias as it is also called—is the inflation of the perceived probability of an event due to a person's preference, or the deflation of the probability of an event due to its undesirability (Bar-Hillel & Budescu, 1995; Krizan & Windschitl, 2007). As mentioned earlier, a football fan's desire for his preferred team to win the upcoming game might cause him to have an inflated perception that they will, in fact, win the game. From football games (Simmons & Massey, 2012), to political elections (Krizan, Miller, & Johar, 2010), to choosing cards from a deck (Marks, 1951), the wishful thinking effect is prolific in many real-life situations, which emphasizes the importance of understanding what factors do and do not influence the magnitude of the desirability bias. Before describing factors that may (or may not) moderate the desirability bias, it is useful to distinguish wishful thinking from a variety of related concepts.

What Is and What Is Not Wishful Thinking?

Wishful thinking, while similar to motivated reasoning, has distinct properties that should be discussed. Motivated reasoning tends to act as an overarching term for a preference bias (Kunda, 1990). However, two unique properties help to distinguish motivated reasoning from the desirability bias. First, the term motivated reasoning generally describes outcomes in a qualitative manner, as opposed to a quantitative outcome prediction or likelihood judgment (Kunda, 1990). For example, motivated reasoning would explain why a professor may describe his or her teaching style as superior to other colleagues, whereas the desirability bias would explain why that professor would inflate the probability that he/she will win an upcoming teaching award. Second, while both motivated reasoning and the wishful thinking effect have their limits regarding how much bias the individual will emplace, they differ in the sense that the constraints placed on motivated reasoning tend to be less stringent than the constraints placed on wishful thinking (Krizan & Windschitl, 2007). Regarding the previous example, the professor can still have the capacity to believe he/she is a superior professor even if his/her student reviews suggest that the lectures are uninteresting. The professor could reason that perhaps the students simply did not put in the time to do the background reading to understand the lecture. However, when predicting whether he or she will get the teaching award, the professor will eventually find out if his or her prediction is correct. While the professor could come up with a variety of reasons to explain why he or she did not get the award, the professor knows that he or she will receive information explicitly indicating the accuracy of his or her prediction. Therefore, people might be less willing to engage in wishful thinking as compared to motivated reasons because of these verifiability constraints (Krizan & Windschitl, 2007).

Wishful thinking is also distinct from overoptimism. Overoptimism can stem from a variety of factors that may or may not include the desire for a particular outcome (Krizan & Windschitl, 2007). For example, someone may overestimate their chance of recovering from a disease, but this overestimation may only be because the side-effects of the medication are not disclosed to the patient. This misinformation may lead an individual to be over-optimistic, even though he or she was not biased by his or her desires to recover quickly. It is, of course, quite possible that a desire for one outcome can play a causal role in overoptimism, however not all overoptimism is the result of the desirability bias.

Wishful thinking is also different from a preference-expectation link, because the preference-expectation link tends to allow for a bidirectional influence. Imagine, for example, that a student is applying to two different universities, one in the top percentile of all universities and the other a moderate safety school. This student may expect that he or she has a greater chance of acceptance to the moderate school based on objective likelihood of getting into a less-competitive school. This expectation may lead the student to prefer this safety school because of the greater chance of success. In other words, simply documenting a correlation between preferences and expectations does not mean that preferences are influencing expectations. It is possible that expectations influence preferences. Wishful thinking, on the other hand, is uniquely the unidirectional influence of preference on expectations.

Finally, the desirability bias must also be distinguished from research that engages exaggerated perceptions of control. A student who wants to ace an exam will likely study to the extent that he/she believes that the desired grade will be obtained. Therefore, even though there might be a relationship between desires and expectations, if a person can exert control over the desired outcome, this relationship might be perfectly rational. That is, if the student wants to ace the exam, and studies very diligently, it is reasonable for this student to think he or she will perform well on the exam. Therefore, in this context it would be impossible to differentiate if the outcome prediction was based on a preference bias, or if it was based on the person's real power to influence that outcome. Wishful thinking, of course, can happen under situations where the person has control, but for the sake of research, studies investigating the desirability bias are restricted to situations where people have little to no control over the outcome of the situation.

Factors that Do and Do Not influence Wishful Thinking

Researchers have investigated the influence of a number of factors on the magnitude of wishful thinking. For example, researchers investigated whether incentives for accuracy could decrease the desirability bias. If the wishful thinking effect was just "cheap talk" in a situation with little to no personal cost, incentives for accuracy should decrease the effect. Simmons and Massey (2012) investigated this question by separating their participants into those who would make predictions about a favorite football team, called partisans, and those who would make predictions about a football team they were neutral about, called neutrals. Overall, they found that partisans were more likely to predict that their team would win an upcoming game as compared to the neutrals. More importantly, they found that partisans were as likely to exhibit the desirability bias when the incentive for an accurate prediction was $5 and when it was $50. These results suggest that people truly believe in the optimistic judgments that they are making. Wishful thinking does not only happen when accuracy incentives are absent (e.g., Marks, 1951), but also when they are present (Simmons & Massey, 2012).

In another study testing factors that influence wishful thinking, Massey, Simmons, and Armor (2010) examined whether wishful thinking would diminish as people gained more experience and feedback about their predictions. In their study, participants were asked to make predictions about whether or not their favorite football team would win an upcoming game, and whether or not a neutral team would win an upcoming game. Participants made these predictions before each week's games across the 17 weeks of the NFL season. After each game the participant was given feedback on the outcome of the game. Participants not only predicted that their preferred team would win more, but they also displayed similar degrees of desirability bias during the first week and during the last week, despite having information of the team's performance throughout. Results illustrated that the wishful thinking effect remains robust despite the participant's experience (Massey et al., 2010).

While experience and incentives for accuracy may not decrease the presence of wishful thinking, there is evidence to suggest that the type of judgment the participant has to make does. In a review of the desirability bias, Krizan and Windschitl (2007) differentiated likelihood judgements from outcome predictions, arguing that likelihood judgments may not yield the same significant wishful thinking effects. When making a likelihood judgments, a participant would be asked, for example, to estimate the probability (from 0% to 100%) that he or she will fully recover from a certain disease. An outcome predictions, on the other hand, would require the participant to indicate whether or not he or she will fully recover from a disease. When making likelihood judgments, people are quite sensitive to the objective probabilities of the events and use this information to inform their judgments.

When making outcome predictions, people do pay attention to the objective probability of an event and they use that information when making their prediction. However, outcome predictions have more flexibility in how people might use the probability information. For example, if someone evaluates the relevant information and concludes that there is a 50% chance that a desirable outcome will occur, he or she might predict that the desirable outcome will happen. However, if someone evaluates the relevant information and concludes that there's a 50% chance that an undesirable outcome will occur, he or she might predict that the undesirable outcome will not happen. Notice that in this hypothetical example, the evaluated likelihoods did not vary depending on the desirability of the outcomes (i.e., they were both 50%). However, the predictions did vary as a function of the desirability of the outcomes. In support of the notion that outcome predictions and likelihood judgments differ, Windschitl, Smith, Rose, and Krizan (2010) found robust wishful thinking effects when soliciting outcome predictions, but not when soliciting likelihood judgments.

Uncertainty is another factor that influences the amount of wishful thinking. The greater the amount of uncertainty, the stronger presence of a desirability bias (Krizan & Windschitl, 2007; Marks, 1951; Windschitl, et al., 2010). Uncertainty refers to the probability of a certain event. Probabilities like 10% or 90% would be regarded with little uncertainty, whereas a 50% chance of an outcome would possess the greatest uncertainty. For example, imagine if a participant must predict whether a red card will be drawn from a deck with five red and five black cards. Uncertainty is high because there is no "optimal" or strategically intelligent decision; there is an equal chance of either card being drawn. On the other hand, imagine if a participant must predict whether a red card will be drawn from a deck with eight red and two black cards. In this situation, uncertainly is lower because the participant can be fairly sure the chosen card will be red. The less certainty in a situation, the greater the chance the individual will engage his or her own interpretations. These interpretations, based on previous research, have consistently shown to engage the desirability bias (Windschitl et al., 2010).

The Influence of Ambiguity

In addition to the uncertainty of outcomes, many decisions involve unknown—or ambiguous—probabilities. Ambiguity is used to describe situations where there is at least some degree of “uncertainty about uncertainty” (i.e., both the outcome and the probability of the outcome are unknown; Lauriola, Levin, & Hart, 2007). Uncertainty and ambiguity are most commonly differentiated by either the presence or absence of outcome probabilities (Ellsberg, 1961; Lauriola et al., 2007). For example, Bier and Connell (1994) presented participants with information regarding a type of medicine’s side effects. The uncertain event listed the probabilities of each of the specific side-effect’s occurrence, and the ambiguous condition only listed the percentage of people who had suffered from any side-effect.

Previous research into ambiguity often involves the analysis of ambiguity-seeking and ambiguity-aversive tendencies. These tendencies are illustrated through a participant’s preference for either an unambiguous and uncertain outcome, or an ambiguous and uncertain outcome. A study conducted by Ellsberg (1961), asked participants to choose between an urn with a known number of two different colored balls, and an urn containing unknown probabilities of the same two colored balls. The desirability bias was measured through a participant’s preference for the colored ball associated with winning points. The greater the chance of the colored ball associated with winning points being chosen, the more likely the participant would prefer the unambiguous and uncertain option. Findings regarding the prevalence of ambiguity-aversive and –seeking tendencies are inconsistent, however (Bier & Connell, 1994). There are situations where people are more likely to avoid ambiguity, like the Ellsberg paradigm described above (Ellsberg, 1961). There are also studies where participants tend to seek ambiguity (Bier & Connell, 1994). Other studies have found that ambiguity-avoidant and ambiguity-seeking tendencies may be situationally dependent, (e.g. how the situation is framed; Kuhn, 1997). Most individuals, however, tend to be indifferent to ambiguity (neither ambiguity-seeking nor ambiguity-averse), and it may be the situational factors that lead individuals to behave in a certain way (Lauriola et al., 2007). Previous research has only sought to distinguish ambiguity from uncertainty in regards to having participants make choices between the two options (Bier & Connell, 1994). Bier and Connell (1994), as mentioned earlier, gave participants four different statements describing a certain medication that the participant would eventually have to choose between. The unambiguous and uncertain option gave the specific percentages of the population who had suffered from each of the two different side effects. The ambiguous and uncertain condition, however, only disclosed the percentage of people who had not suffered from any side-effects. Research has yet to investigate how uncertainty and ambiguity may work simultaneously to influence the desirability bias.

Current Study

The current study was designed to investigate uncertainty, ambiguity, and their influence on the desirability bias. The more that is unknown in a certain context, the more room an individual has for his/her interpretation. It can be argued that when the context is known probabilities, participants may only exhibit a fraction of their bias when making an outcome prediction. Ambiguity, by definition, possess a greater degree of vague evidence than uncertainty, which may allow for an even greater implementation of the desirability bias. Past research has focused on both situations where there is no ambiguity (Marks, 1951), and where there is high ambiguity, like political elections (Krizan, Miller, & Johar, 2010). However, none have sought to investigate varying degrees of ambiguity (i.e. no, low, and high) within the same paradigm and utilizing the same dependent measures. This realistic interpretation of evidence is a practical approach to the heavily researched phenomenon of wishful thinking.

This study differentiated ambiguity into no, low, and high ambiguity conditions. This was illustrated through a square grid with two colors, with varying frequencies of each colored square (i.e. 30%, 40%, 50%, 60%, and 70%). Some participants were shown an ordered grid with the percentages of the respective colored squares, indicating no ambiguity (see Figure 1). Those being tested under low ambiguity were shown the same grid with the percentages omitted (see Figure 2). The high ambiguity condition did not only have the percentages omitted, but the grid was also be scrambled (see Figure 3). Their task was to predict which color the computer will pick at random from the grid. Then, I manipulated desirability by associating some colors with winning points and some with losing points. The participant were scored based on if they chose the critical color associated with winning points. Despite the evidence that the greater the degree of uncertainty, the greater evidence of the desirability bias, no research has been done to investigate the effect of uncertainty and ambiguity on the magnitude of the wishful-thinking effect. This study involved two predictions. First, that there will be evidence of a desirability bias. That is, people will be more likely to predict a color when it is desirable (i.e., associated with winning points) than when it is undesirable (i.e., associated with losing points). Second, past research distinguishes uncertainty from ambiguity in the sense that the more the participant needs to interpret, the more biased the prediction will be. Because of this, it is appropriate to predict that in situations where there is the greatest degree of both uncertainty and ambiguity simultaneously, the desirability bias will increase to a degree not already established by uncertainty or ambiguity alone.

Method

Participants

One hundred nineteen participants (65% Female, $M_{age} = 19.75$, $SD_{age} = 2.12$) were recruited through the Appalachian State University Psychology Subject Pool. The Psychology Subject Pool consists of students enrolled in introductory and intermediate Psychology classes who have elected to enter the Psychology Subject Pool to fulfill an Experiential Learning Credit (ELC) for the course. Participants were given candy for their involvement. This study was approved by the Institutional Review Board at Appalachian State University (see Appendix A).

Design

The research methodology employed a 3 (ambiguity condition: no ambiguity, low ambiguity, high ambiguity) x 5 (frequency condition: 30%, 40%, 50%, 60%, 70%) x 2 (desirability condition: critical color is desirable vs. critical color is not desirable) x 2 (block condition: the 20 rounds were divided into two blocks, with each block consisting of 10 rounds) repeated measures design. The ambiguity condition was manipulated between-subjects, while the frequency condition, desirability condition, and block condition were manipulated within-subjects.

Prediction Task

The participants read instructions about their task. Specifically, they were informed that their task was to predict which of two colors the computer would pick at random from a grid of 200 colored squares. Before making their prediction, the participants received two pieces of information. First, the participants were informed that one color was associated with either winning or losing points. For example, a participant might be told that if the computer randomly picks a red square, they will win 100 points. The second color was not associated with either winning or losing points. This information was available for four seconds. Second, the point information would disappear and the participant would be shown the grid of 200 colored squares, each with two different color squares. This information was also available for four seconds. The grid information would then disappear, and the participant would be asked to predict which of the two colors the computer would pick at random from the grid.

Procedure

Each participant who met the age and subject pool requirements (18+ and enrolled in an Appalachian State University Psychology course) was invited to take part in the study. After arriving to the lab, the participants were given an informed consent document (see Appendix B) that briefly stated the purpose of the research study, the risks, an explanation that participation is voluntary, and the contact information of the Principal Investigator. After reading the consent form and asking any questions, participants were instructed to complete the rest of the study on the provided computers. The participants then proceeded to each round of the experiment.

As mentioned above, each round started by describing which of the two colors was associated with winning or losing points. In some trials, the “critical” color was associated with winning 100 points, and in others, the "critical" color was associated with losing points 100 points. The participants were then shown a grid with 200 squares. The participants were randomly assigned to one of the three ambiguity conditions: no ambiguity, low ambiguity, and high ambiguity. In the no ambiguity condition, participants were shown a 200-square grid consisting of two colors (see Figure 1). These two colors were randomly chosen by the computer from a pool of ten different color combinations. For the sake of explanation, this type of grid (along with the grid later described for the low ambiguity condition) will be known as "orderly". In addition to an orderly grid, the no ambiguity condition also presented the percentages of each color (i.e., 30%, 40%, 50%, 60%, and 70%). In the low ambiguity condition, participants saw the orderly grid with the percentages of the colors omitted (see Figure 2). In the high ambiguity condition, participants not only had the percentages omitted, but the grid was also scrambled (see Figure 3). The scrambled nature of the grid was randomized for each grid presentation.

Across each round, two features of the grid changed. First, for half the rounds, the critical color was associated with winning 100 points (making that outcome more desirable) and for the other half the rounds, the critical color was associated with losing 100 points (making that outcome less desirable). Second, there were 30%, 40%, 50%, 60%, or 70% of the critical color. Therefore, there were 10 possible combinations of desirability and frequency. The order of these 10 combinations was randomized within two blocks of 10 rounds each—for a total of 20 rounds.

After completing the 20 rounds, participants then completed demographic questions (i.e., age and gender), were debriefed, credited for their participation in the study, and asked to leave.

Results

Wishful Thinking

For each participant, I measured the number of times he or she predicted that the computer would pick the color associated with either winning or losing points, or the "critical color". I next conducted a 3 (ambiguity: no ambiguity, low ambiguity, or high ambiguity) x 5 (frequency: 30%, 40%, 50%, 60%, 60%, 70%) x 2 (block: first block of ten vs. second block of ten) x 2 (desirability: critical color is desirable vs. the critical color is not desirable) repeated measures ANOVA of the number of times people predicted that the computer would pick the critical color. The ambiguity condition was manipulated between-subjects while frequency, block, and desirability were manipulated within-subjects. This analysis revealed a main effect of desirability, $F(1,115) = 103.80$, $p < .001$, $\eta_p^2 = .474$. Participants were significantly more likely to choose the critical color if it was associated with winning points, as opposed to if the critical color was associated with losing points. In other words, there was a significant wishful thinking effect. There was also a main effect of frequency, $F(4,112) = 75.03$, $p < .001$, $\eta_p^2 = .728$. Participants were sensitive to the relative frequency of the colors in the grid. There was an interaction between desirability and frequency, $F(4,112) = 3.66$, $p = .008$, $\eta_p^2 = .116$. As shown in Figure 4, participants exhibited a greater desirability bias when more uncertainty was present (e.g., when there were 50% critical color boxes), and less of a desirability bias when less uncertainty was present (e.g., when there were 30% critical color boxes). This is in line with previous research showing that greater uncertainty leads to a larger desirability bias (e.g., Windschitl et al., 2010).

The above results demonstrate that there was a wishful thinking effect, participants were sensitive to the frequency of the critical color, and there was a larger wishful thinking effect with greater uncertainty. As a test of the hypothesis that there would be a larger wishful thinking effect with more ambiguity, I examined the interaction between desirability and ambiguity. This interaction was significant, $F(2,115) = 5.39$, $p = .006$, $\eta_p^2 = .086$. However, as shown in Figure 5, contrary to the hypothesis, participants in the high ambiguity condition exhibited a significantly smaller desirability bias compared to those in the no ambiguity condition.

In addition to the significant effects described above, there was an interaction between block and desirability, $F(1,115) = 7.42$, $p = .007$, $\eta_p^2 = .061$. Participants exhibited a greater amount of wishful thinking during the second block compared to the first block.

There was no main effect of block, $F(1,115) = 0.32$, $p = .58$, $\eta_p^2 = .003$. This means that participants were as likely to choose the critical color in the first ten rounds as they were in the second ten rounds of the experiment. There was also no main effect of ambiguity, $F(2,115) = 2.14$, $p = .12$, $\eta_p^2 = .036$. This means that participants in the no, low, and high ambiguity conditions were all equally likely to choose the critical color.

There were no more two, three, or four way interactions. Specifically, there was no block x ambiguity interaction, $F(2,115) = 0.17$, $p = .84$, $\eta_p^2 = .003$, frequency x ambiguity interaction, $F(8,226) = 1.41$, $p = .19$, $\eta_p^2 = .048$, or block x frequency interaction, $F(4,112) = 1.71$, $p = .15$, $\eta_p^2 = .057$. There was also no block x desirability x ambiguity interaction, $F(2,115) = 0.23$, $p = .80$, $\eta_p^2 = .004$, block x frequency x ambiguity interaction, $F(8,226) = 1.03$, $p = .42$, $\eta_p^2 = .035$, desirability x frequency x ambiguity interaction, $F(8,226) = 1.33$, $p = .23$, $\eta_p^2 = .045$, or block x desirability x frequency interaction, $F(4,112) = 0.49$, $p = .74$, $\eta_p^2 = .017$. Finally, there was no block x desirability x frequency x ambiguity interaction,

$F(8,226) = 0.89$, $p = .53$, $\eta_p^2 = .031$. See Table 1 for a summary of all of the previously described results.

Accuracy in Predictions

As shown in Figure 6, I also measured how many times the participants chose the "optimal color". This would be the color associated with the higher percentage of squares on the grid. For example, regardless of whether a particular color was associated with winning or losing points, predicting the color with 60% of the squares in the grid would be the optimal prediction. The 50% frequency condition was omitted from the optimal choice calculation because no optimal choice is available (i.e., either option is equally likely). A one-way ANOVA revealed that the number of optimal choices differed across the three ambiguity conditions, $F(2,115) = 4.43$, $p = .014$, $\eta_p^2 = .072$. Post-hoc analyses revealed that those in the high ambiguity condition ($M = 12.45$, $SD = 2.44$) were significantly more likely to choose the optimal color option than those in the no ambiguity condition ($M = 10.77$, $SD = 2.43$), ($p = .004$). The low ambiguity condition ($M = 11.70$, $SD = 2.44$) was not significantly different from the high ambiguity condition ($p = .163$) or the no ambiguity condition ($p = .098$). In summary, these analyses reveal that not only did the participants in the high ambiguity condition exhibit less bias, but they also made more accurate predictions.

Demographic Information

For each participant, I also calculated a "wishful thinking index". This was calculated by subtracting the percentage of the time the participant chose the critical color associated with losing points from the percentage of the time the participant chose the critical color associated with winning points. Higher numbers indicated a greater degree of wishful thinking. Males ($M = 0.30$, $SD = 0.37$) and females ($M = 0.32$, $SD = 0.33$) did not differ significantly regarding the amount of wishful thinking they exhibited, $t(116) = -0.19$, $p = .85$. Similarly, there was no relationship present between participants' age and magnitude of wishful thinking, $r(118) = .06$, $p = .48$.

Discussion

People make a variety of decisions every day, and many of these decisions can be influenced by what that person may or may not want, and how much information is present. This study sought to investigate the effects of both uncertainty and ambiguity on the wishful thinking effect. Previous research demonstrated that people tend to exhibit a higher desirability bias when the situation is more uncertain (Krizan & Windschitl, 2007; Marks, 1951; Windschitl, et al., 2010). Because ambiguity can be described as "uncertainty about uncertainty", the hypothesis was that in situations with not only the highest degree of uncertainty, but also the highest degree of ambiguity, people would exhibit more of a wishful thinking bias. However, contrary to my hypothesis, in situations with more ambiguity, participants tended to exhibit less of a desirability bias. That is, while the hypothesis of the more uncertainty the more wishful thinking remained supported, more ambiguity actually led to less wishful thinking. In addition, in situations with the highest degree of ambiguity, participants also made better decisions. This is important because it rules out the alternative explanation that those in the high ambiguity condition were either choosing colors randomly, or because they did not understand the nature of the grid.

Explanations

There are a variety of possible reasons why the results of my study differed from my hypothesis. Some can be explained by the processing of information, the process of making a decision, and the ability to explain a decision.

We may be led to believe that grounding information in objective, numerical information may assist people in making the best judgments. However there is evidence to suggest that people perceive numerical information differently when they are motivated. Lench, Smallman, Darbor, and Bench (2014) found that people perceive probabilistic information as having more variance when they desire a certain option. Specifically, participants were asked to play blackjack and told that they could win $1 for a certain card, and lose $1 for another. Participants were told to give probability estimates about the likelihood of a certain card being chosen. For example, if they were told that the probability of drawing a 3 was 40%, participants would estimate the range, or confidence interval, in which that outcome may occur, giving the lowest and the highest probability (e.g. 20-50%). Lench et al. (2014) found that in situations where the participant was motivated to arrive at a particular conclusion (winning versus losing money), the participant interpreted the same original and objective probability (i.e. 30%) as having more variance.

These results are important for my findings because it could mean that participants in the no ambiguity condition, because they were given the probabilities of the two colors, could have interpreted this number to illustrate greater variance than the number we presented. This increased variance in the likelihood could have motivated participants to engage in wishful thinking and choose the desirable color, even if its probability of being chosen was under 50%.

It is also possible that more bias was present in situations that were less ambiguous because of the participant's process of formulating a decision. For the condition with the highest degree of ambiguity, the participant must work towards a conclusion. Not only are the percentages omitted, but the grid is scrambled, meaning that the participant is presented with all of the information together (as opposed to one color on above the other). This display of the grid may allow those in the high ambiguity condition to actively work towards their conclusion, making their decisions not only less biased, but more optimal. Those in the no ambiguity condition had the information readily given, meaning that there was no pressure to grapple with it. In short, it is harder to be biased when you are the one making sense of the information given.

The high ambiguity condition asks what is more likely, while the no ambiguity condition asks what is possible. In a grid where the percentages are 70% versus 30%, even though 70% is more likely, 30% is still possible. In the high ambiguity condition, the participant is working with the scrambled grid and determining what is more likely, which could then lead to a decreased degree of bias.

Discrepancies in the amount of wishful thinking could also be explained by the global processing advantage. Research has found that the processing of features as a whole (global processing) can be better than processing features as individual parts, called local processing (Kimchi, 1992). The no ambiguity grid is designed so that one color in its entirety is above the other color. In addition, there is also numerical information present. Participants could have interpreted this as at least three individual pieces, whereas in the high ambiguity condition, the colors were scrambled together, and there was no numerical information present. Participants could have interpreted this grid more as one, whole piece. Not much research has been done investigating how the differences of global versus local processing could influence decision making and wishful thinking, but it could explain the differences I observed in my results.

Limitations

This study took place on a computer, in a lab, using colored grids. This application of testing the effects of ambiguity and uncertainty on the amount of wishful thinking while informative, should be expanded in order to also include more realistic situations. While a similar grid was used in Bar-Hillel and Budescu (1995), this was the first time using this specific program to test uncertainty and ambiguity with colored squares. It would be helpful to replicate this construct in another type of program in order to determine that the results were clearly due to the hypothesis that I tested. For example, instead of using a grid, it may be helpful to use different colored balls in a jar, or if one wanted to be able to generalize to more realistic situations, maybe implement a prediction task based on different amounts of information on a resume or job application.

Future Directions for Research

Because this study discovered a finding contrary to what I would have believed, it is important to perform additional studies in order to expand the generalizability of the results. For example, it would be appropriate to run a study that mimics mine in nature, except that it is conducted in a real-world setting. Examples of this could be asking people to make decisions about their favorite sports team and manipulating the amount of information they receive, or asking people to make decisions about job candidates while manipulating the desirability of the job candidate and the information given. This real-world application of my thesis would serve to offer breadth to the generalizability of the results.

Since this was the first time this specific computer program was used to manipulate ambiguity and uncertainty, and measure wishful thinking, it would be appropriate to test different manipulations of ambiguity. For example, in a high ambiguity condition, instead of scrambling the grid, there could be a grid with a certain amount of bars “greyed out” so that the participant would have an idea of the frequencies of each color, but it would still be ambiguous in nature. I believe that in this context, we could still observe the same results (i.e. more ambiguity causes less bias), but this would eliminate the probabilistic versus visual information issue I discussed earlier. If the same results were observed, this would not only eliminate that issue, but it would also increase the generalizability of my results to include various measures of ambiguity.

To combat the specific issue of the discrepancies between the processing of visual and probabilistic information, there could be a study that eliminates the grids all together, and only uses probabilistic information. This would look like a study manipulating the probabilistic ranges. For example, say that people had to make decisions about colored balls in a jar. People in the no ambiguity condition would be told that 3/10, or 30% of the balls are black, which ball do you think the computer would pick? People in the high ambiguity condition would be told that 2-4/10, or 20-40% of the balls are black. The ranges and the desirability of the balls would be manipulated in order to mimic the paradigm present in my study, but it would eliminate the issue of possible differences in information processing.

To expand on the relationship between ambiguity and wishful thinking, I would be interested in investigating whether or not, if given the choice, people would decrease (or eliminate) ambiguity. This of course would come at a cost, but previous research describes that people have a tendency to be ambiguity-averse. Would the presence of choice within the ambiguity and wishful thinking paradigm impact the amount of desirability bias people exhibit in their decisions? Now that I have established that the relationship between ambiguity and wishful thinking is more complicated than I originally thought, my next step would be to investigate the various factors that may exacerbate or mitigate this relationship.

Conclusion

Given the results of the current study, it is important that more research be done into how the level of ambiguity might influence wishful thinking. It is a repeated notion that the more information a person has, the better decision they will make. We rely on this idea in many situations that can have significant effects on our way of life (e.g., political elections and trials by a jury). What if this is not true? How should information and its amount be presented in a way that will allow the subject to make not only the most informed, but the least biased decision? There is evidence to suggest that experts in a field could lend to being more biased (Birnbaum & Stegner, 1979), and informed sports fan display the greatest degree of bias (Massey et al., 2011). Maybe it is no longer wise to assume that people will interact with the information they are given rationally. In order to combat this paradox, it is important that the relationship between ambiguity and wishful thinking is explored further.

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Appendix A

RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)
Study #: 16-0073
Study Title: Uncertain Outcomes
Submission Type: initial
Expedited Category: 7. Research on Group Characteristics or Behavior, or Surveys, Interviews, etc.
Approval Date: November 2, 2015
Expiration Date of Approval: November 1, 2016
The Institutional Review Board (IRB) approved this study for the period indicated above. The IRB found that the research procedures meet the expedited category cited above. IRB approval is limited to the activities described in the IRB approved materials, and extends to the performance of the described activities in the sites identified in the IRB application. In accordance with this approval, IRB findings and approval conditions for the conduct of this research are listed below. The IRB determined that this study involves minimal risk to participants. The IRB waived the requirement to obtain a signed consent form for some or all subjects because the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context.

Approval Conditions:

Appalachian State University Policies: All individuals engaged in research with human participants are responsible for compliance with the University policies and procedures, and IRB determinations.

Principal Investigator Responsibilities: The PI should review the IRB's list of PI responsibilities. The Principal Investigator (PI), or Faculty Advisor if the PI is a student, is ultimately responsible for ensuring the protection of research participants; conducting sound ethical research that complies with federal regulations, University policy and procedures; and maintaining study records.

Modifications and Addendums: IRB approval must be sought and obtained for any proposed modification or addendum (e.g., a change in procedure, personnel, study location, study instruments) to the IRB approved protocol, and informed consent form before changes may be implemented, unless changes are necessary to eliminate apparent immediate hazards to participants. Changes to eliminate apparent immediate hazards must be reported promptly to the IRB.

Approval Expiration and Continuing Review: The PI is responsible for requesting continuing review in a timely manner and receiving continuing approval for the duration of the research with human participants. Lapses in approval should be avoided to protect the welfare of enrolled participants. If approval expires, all research activities with human participants must cease.

Prompt Reporting of Events: Unanticipated Problems involving risks to participants or others; serious or continuing noncompliance with IRB requirements and determinations; and suspension or termination of IRB approval by an external entity, must be promptly reported to the IRB.

Closing a study: When research procedures with human subjects are completed, please complete the Request for Closure of IRB review form and send it to irb@appstate.edu.

Appendix B

Consent to Participate in Research

Uncertain Outcomes
Principal Investigator: Cassandra Smith
Faculty Advisor: Andrew R. Smith - smithar3@appstate.edu
Department of Psychology

You are invited to participate in a study about how people make decisions in uncertain situations. In this study, you will be given information and be asked to complete a task in which you make decisions. You will also be asked questions about your personality, age, and gender.

All of your responses in this study will be anonymous. In other words, your responses cannot be linked to you in any way. Your participation in this study you will earn you 1 ELC via the SONA system.

There are no foreseeable risks to participating in this study beyond those ordinarily encountered in daily life. While there may be no direct benefit to you for participating, this research may help us to better understand how people make judgments in uncertain situations. All of your responses will be collected anonymously to maintain confidentiality.

Your participation in this study is completely voluntary. You can decide to stop at any time for any reason and you many skip any question you would prefer not to answer. You will receive no penalty for stopping this study early. In order to fulfill your ELC requirement, there are research and non-research alternatives to participating in this study. For example, one non-research option is to read an article and write a 1-2 page paper summarizing the article and your reaction to it. This would be worth 1 ELC. Additionally, there are other studies you may participate in to meet this requirement. More information about this option can be found at: psych.appstate.edu/research. You may also wish to consult your professor to see if other non-research options are available.

Participation in this study will take no longer than 30 minutes.

This research project has been approved on November 2, 2015 by the Institutional Review Board (IRB) at Appalachian State University. This approval will expire on November 1, 2016 unless the IRB renews the approval of this research.

If you have any questions or concerns about the nature of this research or please contact:
Dr. Andrew R. Smith
828-262-2272
smithar3@appstate.edu

Or, you can contact the Appalachian State University IRB office at irb@appstate.edu.

By continuing to the survey, I acknowledge that I am at least 18 years old, have read the above information, and provide my consent to participate under the terms above.

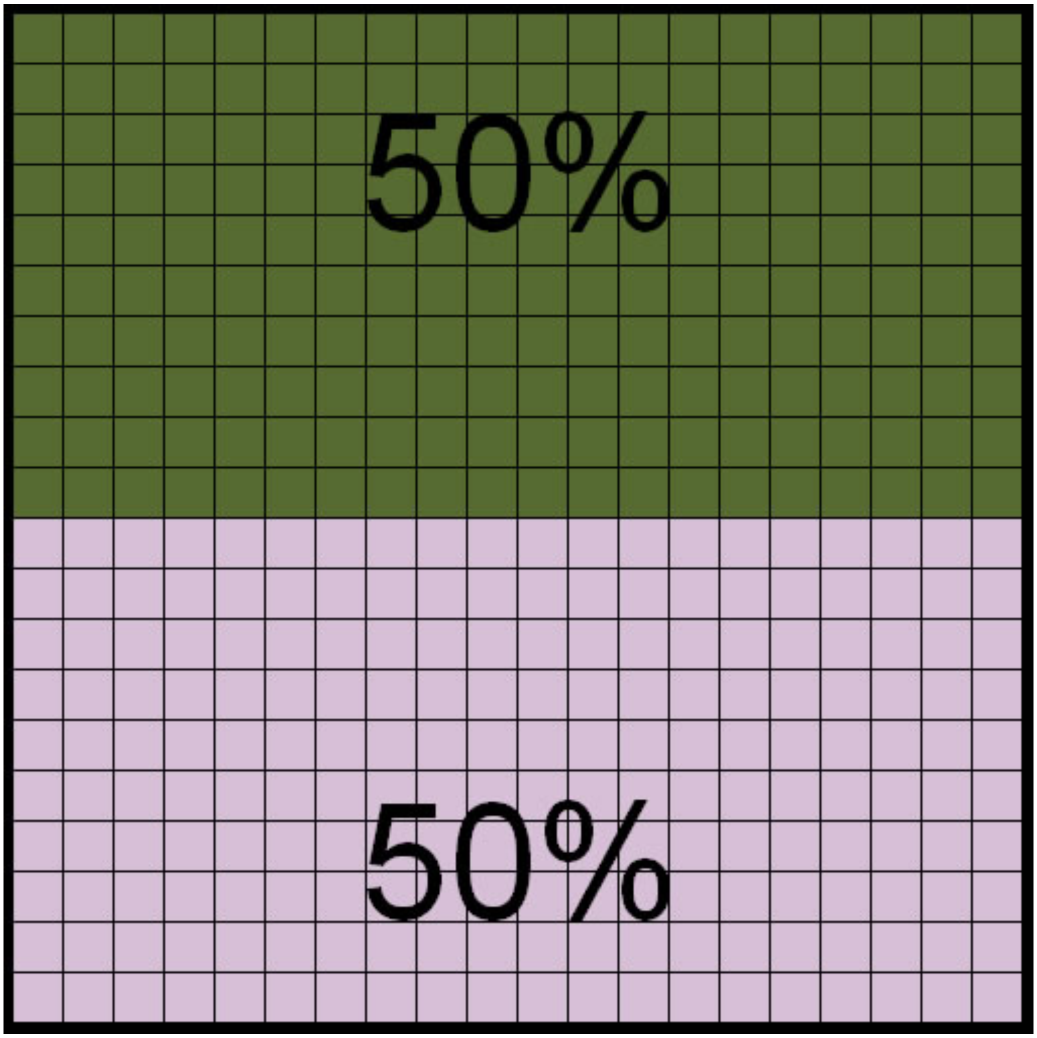

Figure 1. Example of the grid displaying no ambiguity. The grid is ordered and the probabilities of each respective color are displayed, allowing for high uncertainty, but no ambiguity.

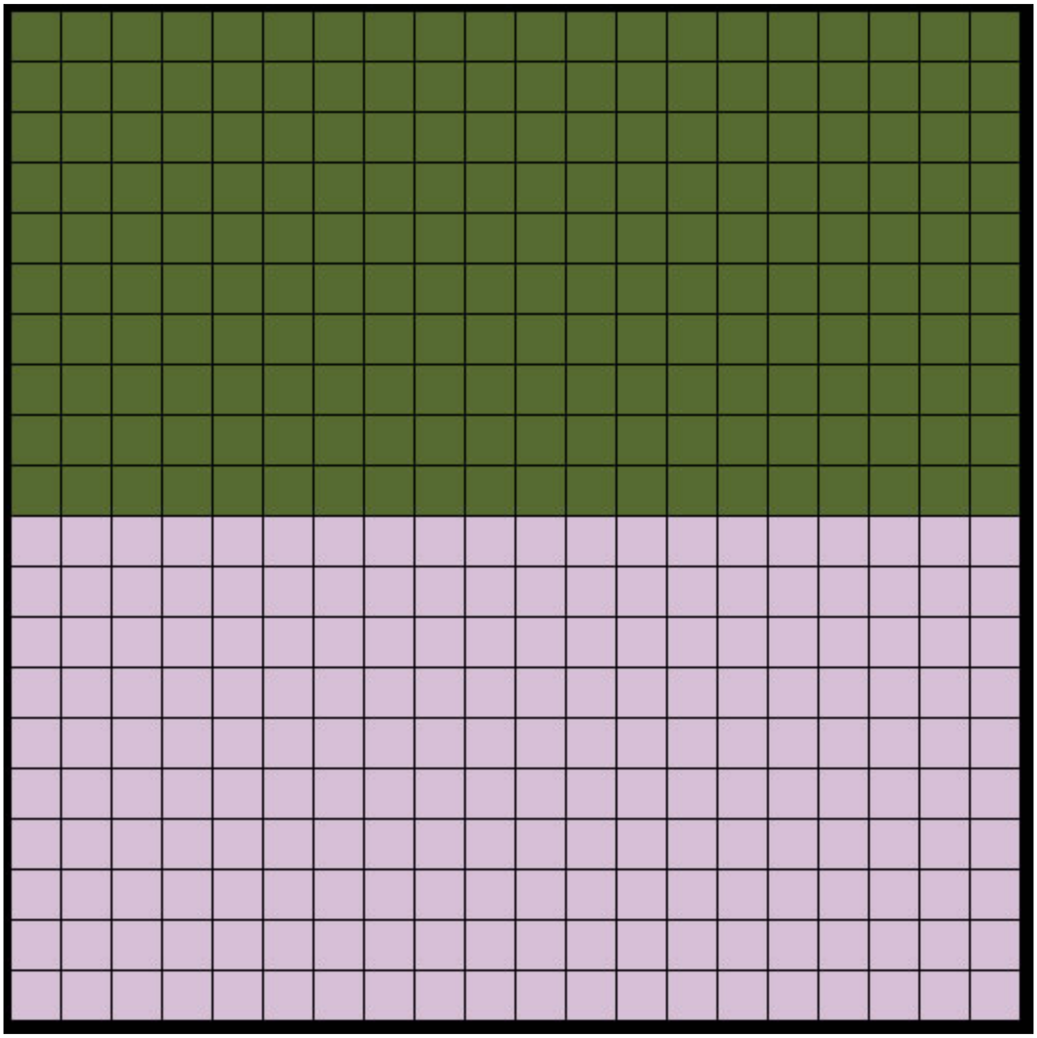

Figure 2. Example of the grid displaying low ambiguity. The grid is ordered and the probabilities of each respective color are omitted, allowing for both uncertainty and a low degree of ambiguity.

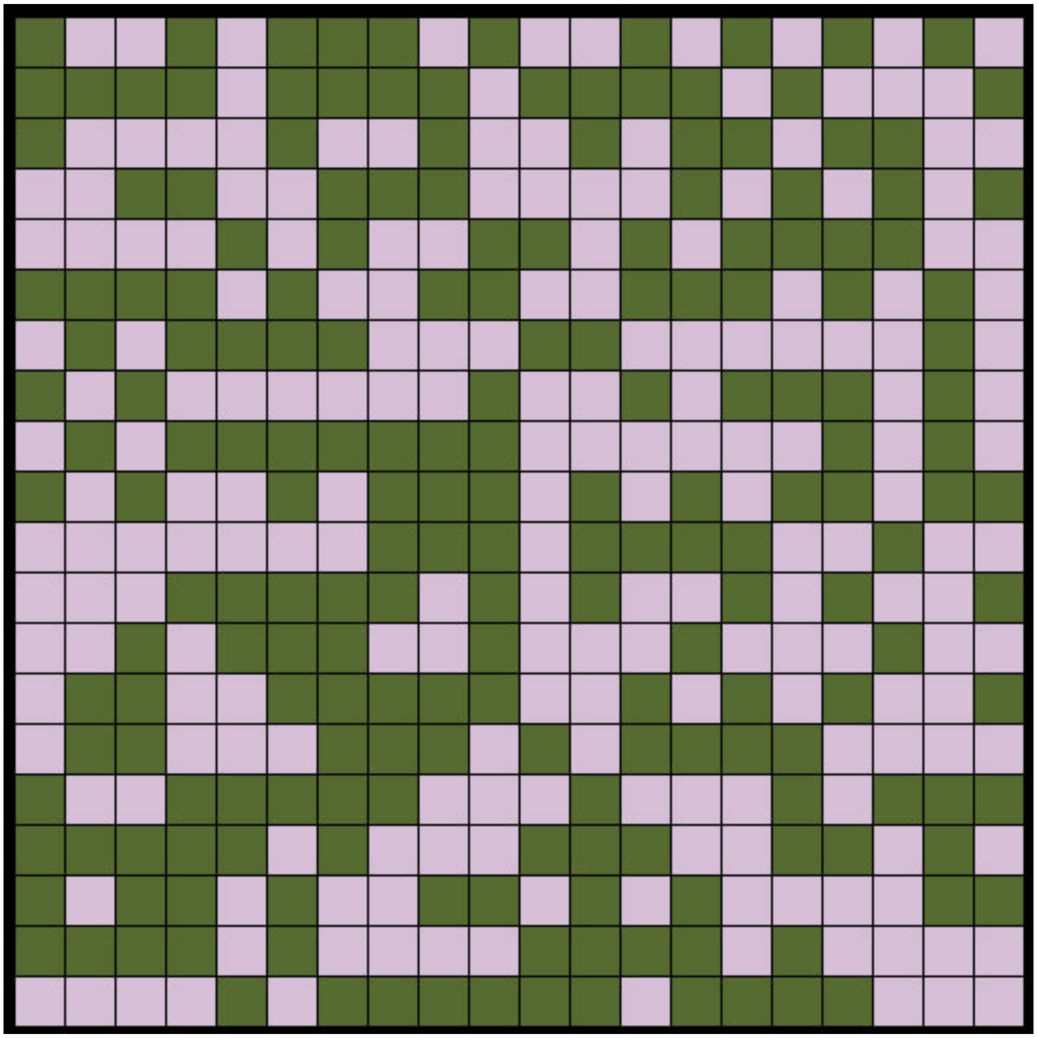

Figure 3. Example of the grid displaying high ambiguity. The grid is scrambled and the probabilities of each respective color are omitted, allowing for both high uncertainty and high ambiguity.

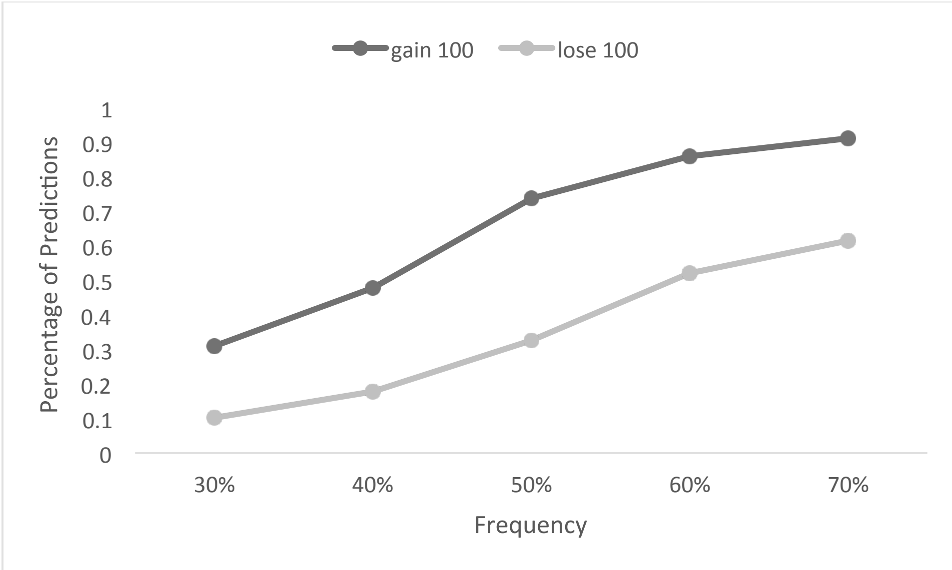

Figure 4. The percentage of time participants predicted the critical color for the gain and loss rounds across the five different frequencies of the critical color.

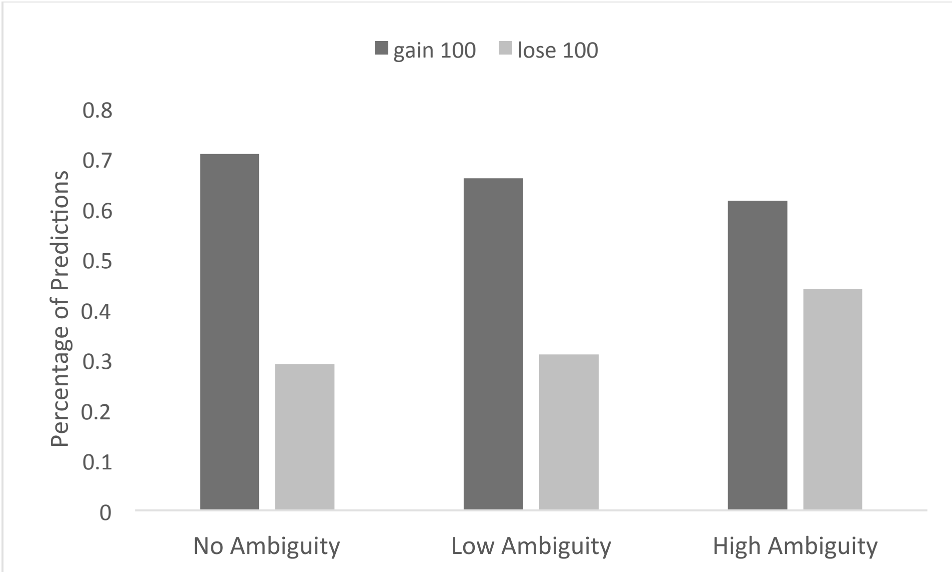

Figure 5. The percentage of time participants predicted the critical color for the gain and loss rounds across the three different ambiguity conditions.

Table 1

ANOVA Table

	df	*F*	*η*	*p*
Block	1,115	0.32	.003	.58
Desirability	1,115	103.80	.474	<.001*
Frequency	4,112	75.03	.728	<.001*
Ambiguity	2,115	2.136	.036	.12
Block*Ambiguity	2,115	0.17	.003	.84
Desirability*Ambiguity	2,115	5.39	.086	.006*
Frequency*Ambiguity	8,226	1.41	.048	.19
Block*Desirability	1,115	7.42	.061	.007*
Block*Frequency	4,112	1.71	.057	.15
Desirability*Frequency	4,112	3.66	.116	.008*
Block*Desirability*Ambiguity	2,115	0.23	.004	.80
Block*Frequency*Ambiguity	8,226	1.03	.035	.42
Desirability*Frequency*Ambiguity	8,226	1.33	.045	.23
Block*Desirability*Frequency	4,112	0.49	.017	.74
Block*Desirability*Frequency*Ambiguity	8,226	0.89	.031	.53

Note: Asterisks mark significant p-values at the $p<0.05$ level.

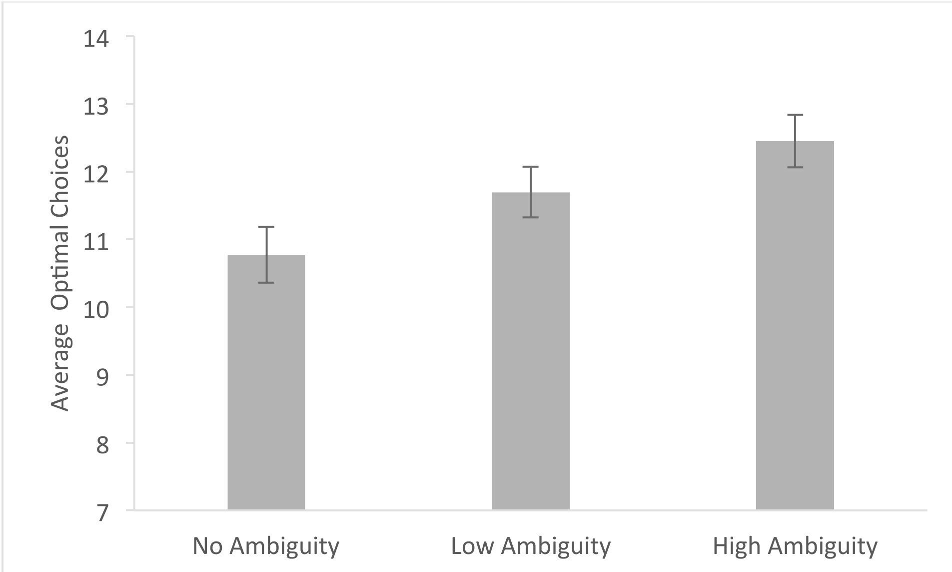

Figure 6. The number of times the participant chose the "optimal" color. The optimal color refers to the color associated with the greater frequency on the grid. The 50% frequency condition was omitted because no optimal choice was present.