

Quantum Enhanced Decision Making

Mentee: Logan Grove

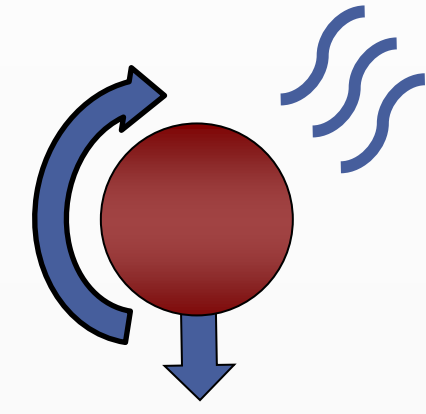
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Introduction

Quantum Information (Nielsen & Chuang, 2000)

- **Bits:** Computers run on bits- 1s (the presence of charge) or 0s (no charge)
- **Qubits:** A particle can be a quantum bit with 1 and 0 states
 - "1" states have more energy than "0" states
 - They can be physically spun in space by adding energy
 - They are a physical representation of a bit
 - If used in computing, they are much faster due to QM
- **Superposition:** The combined state of probabilities with no decided state
 - Impossible to tell what state before measurement
 - Both the 1 and the 0 states at the same time
 - The physical position of the qubit determines the probability of measuring each result
- **Entanglement:** Connect two particles in such a way that they are essentially the same particle. Allows measurements to be done so that the result of measuring one allows the experimenter to predict with absolute certainty that the second particle is the opposite value.
 - Ex- Particle is measured to be 1, the other is with 100 percent certainty, a 0, as this is the opposite state.



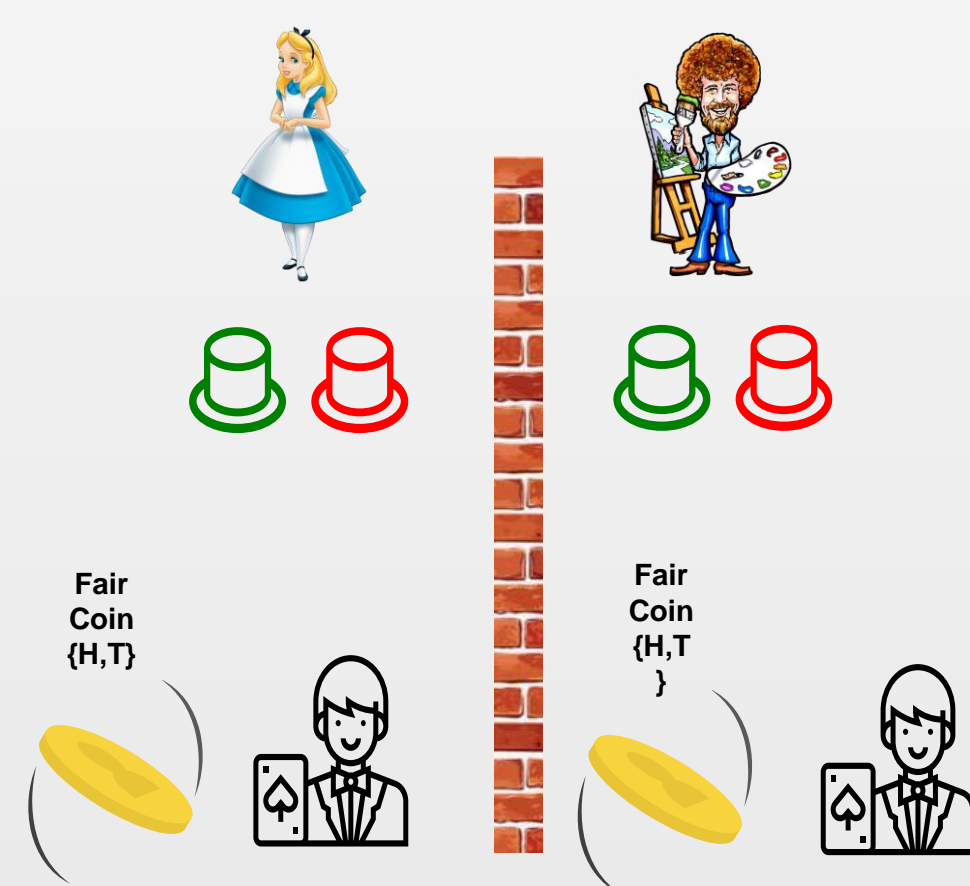
Measurement:



Bell Experiment

Casino Game - Alice and Bob:

- Two fictional characters, Alice and Bob
- Each enter the same casino
 - Casino flips a fair coin for each of them
 - Each can only see their own coin
- Both also have a button, Red or Green
 - If they press different colors, they can play
 - If same colors, they skip they neither gain nor lose money
- When playing, they only get money if both coins show heads (HH)
 - Lose money otherwise
- House will win majority of the time, and there is no long term strategy for winning
- No in-game communication, but they can decide on any strategy beforehand

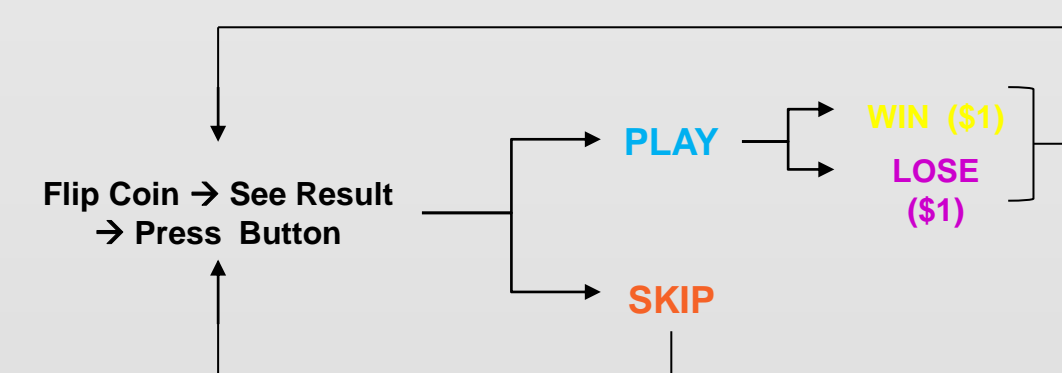


Example play:

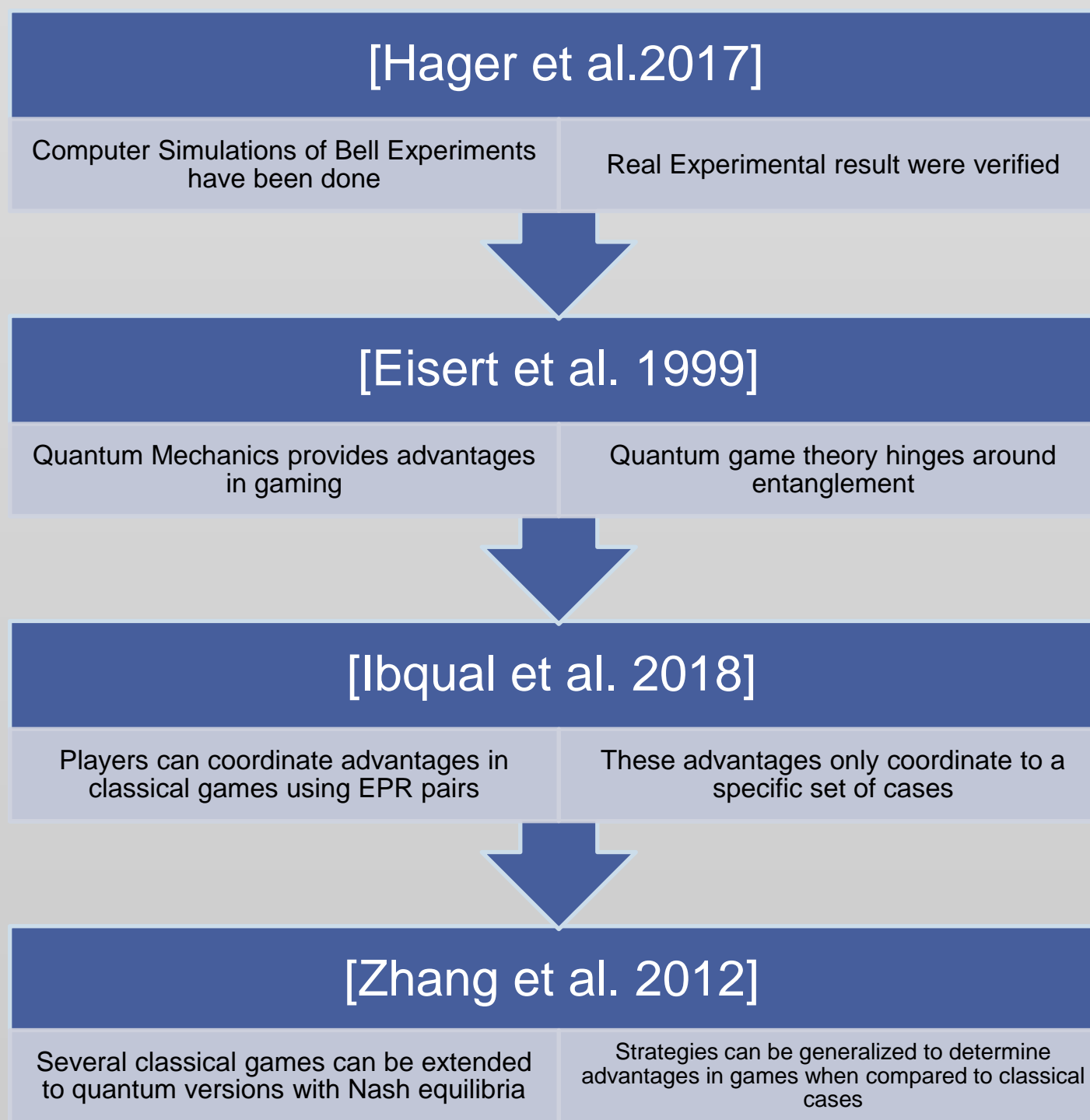
- If Alice gets a tails, she will not play
 - She knows she cannot win
- If Alice gets a heads, she will most likely play, but cannot be sure of a favorable outcome
- Quantum mechanics can provide a solution where they can win in the long run
 - Q-Move allows both to pick H with a higher certainty
 - Presence of the quantum qubit forces HH if operated on correctly
 - Violation of the Bell Inequality
 - Cannot be done classically, but entanglement violates this

Coding and Simulations

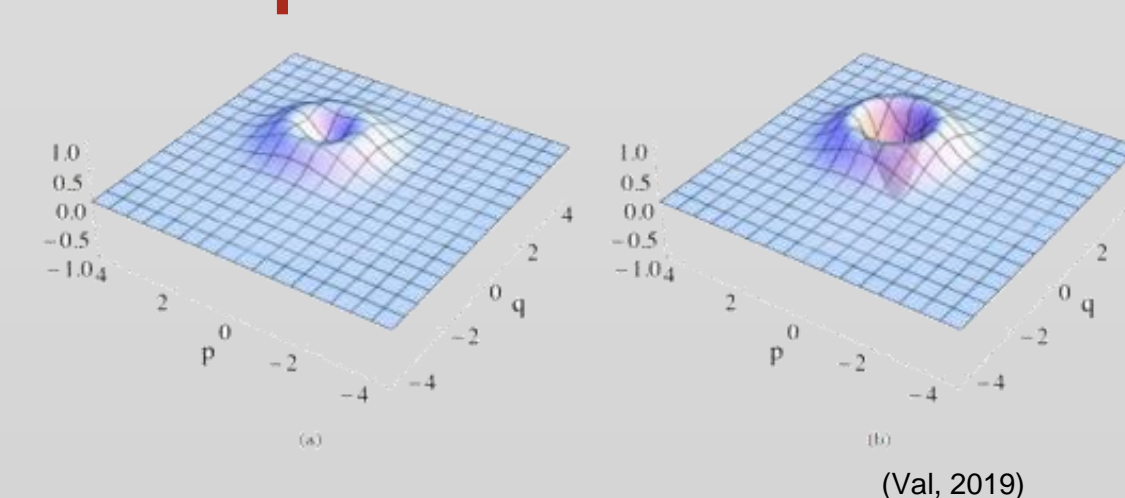
- Python is a programming language
- I will use to write code that runs simulations of Bell's experiment
- Probability analysis of the results
 - Use machine learning to find optimal strategies for "casino games"
 - Will help to understand the experiment



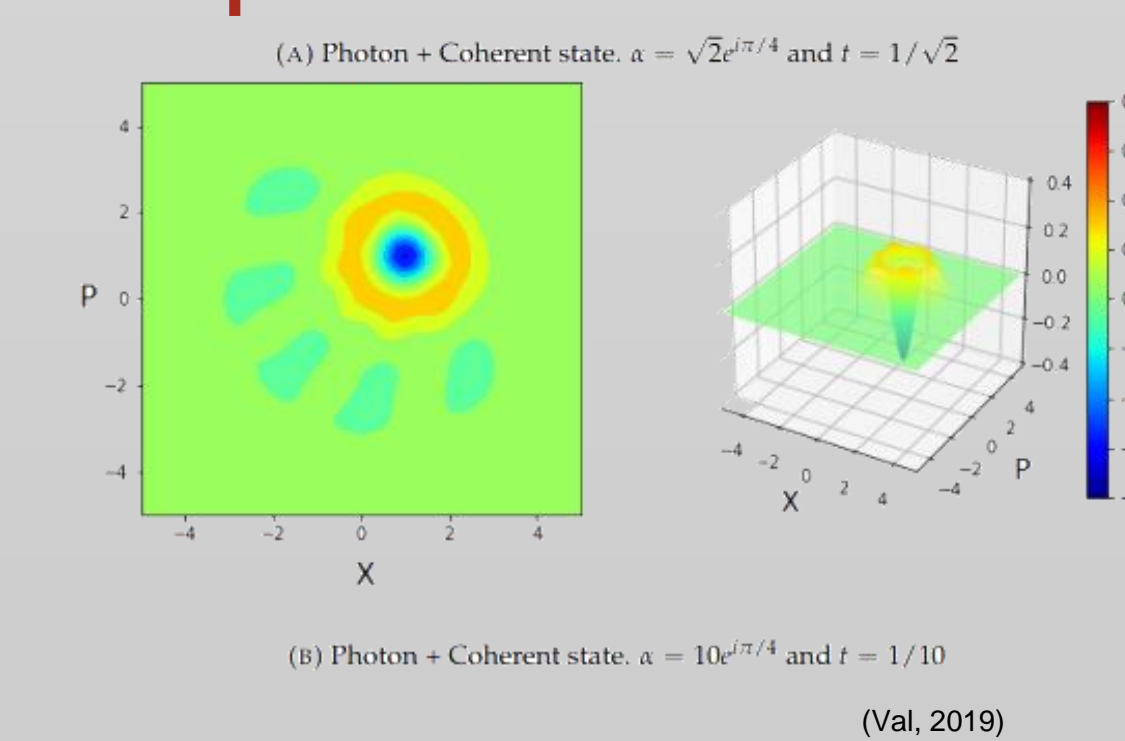
Literature Review



Experimental Results



Computer Simulated Results



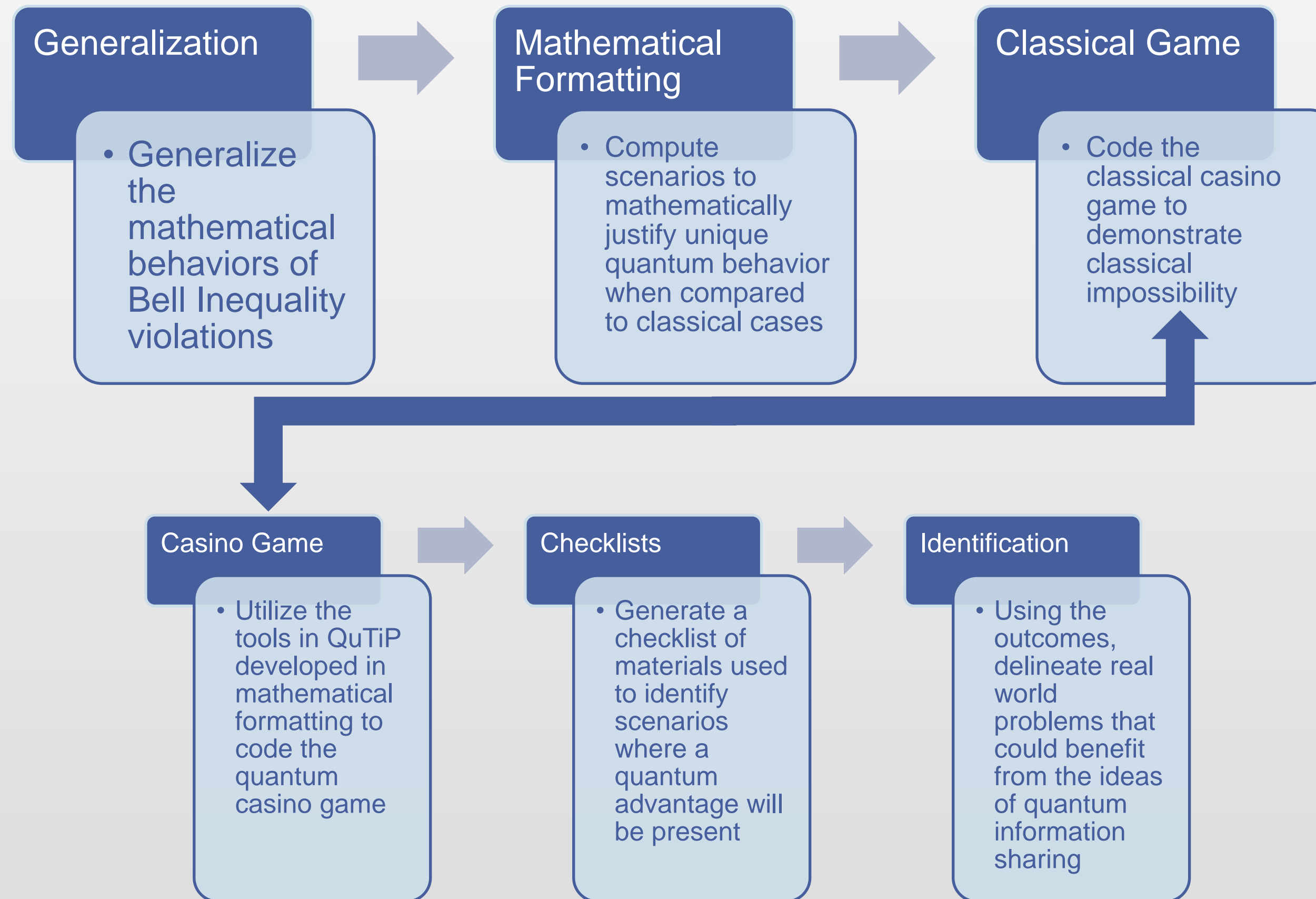
Hypothesis

Gap in the Research: Lack of simulation research surrounding Bell inequality and its applications to real life.

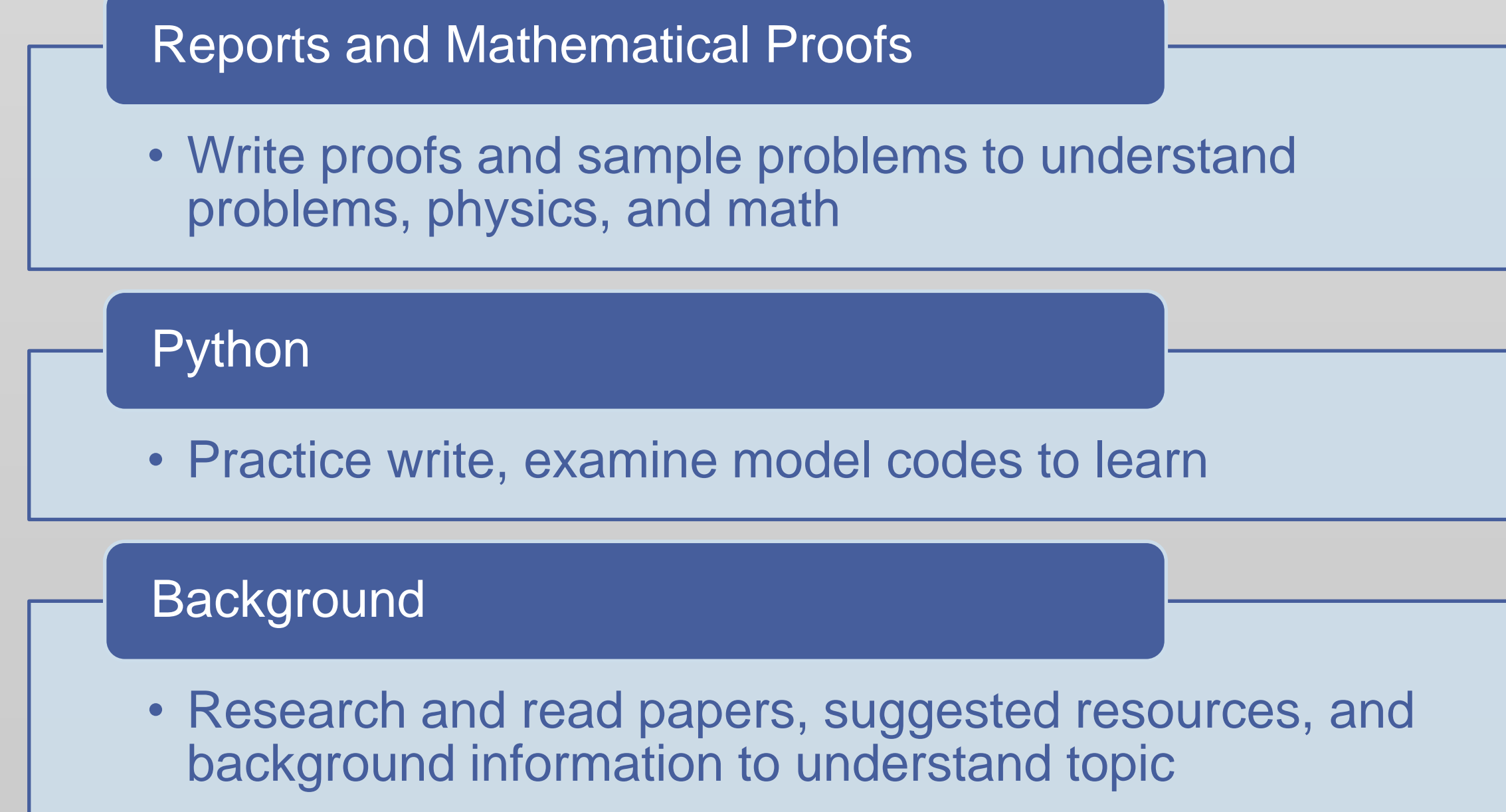
Goals: The goals of this study are to find more real world examples that can profit from the use of quantum communication.

Hypothesis: Can we find real world protocols that admit a straight forward enhanced Quantum solution with respect to the classical available solutions?

Methodology



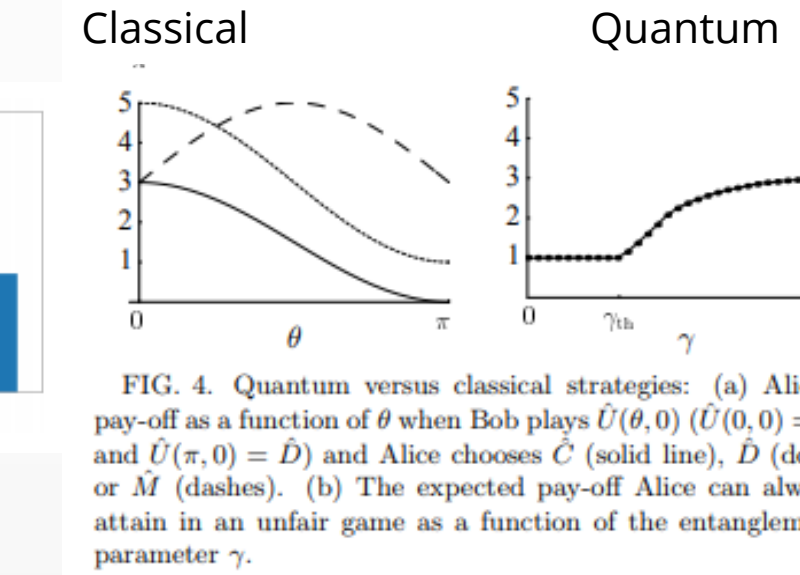
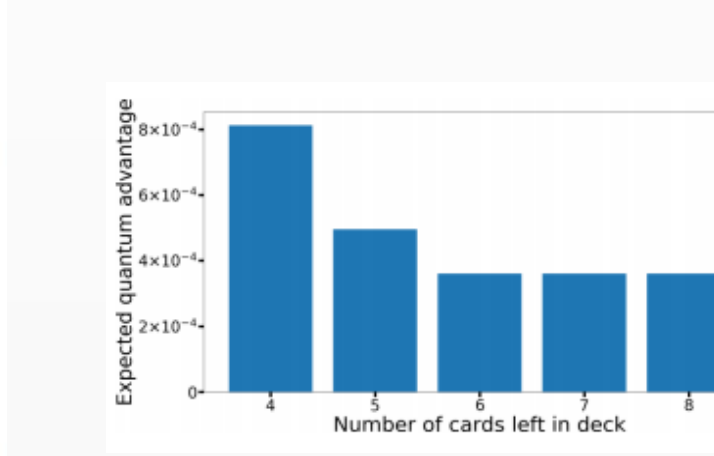
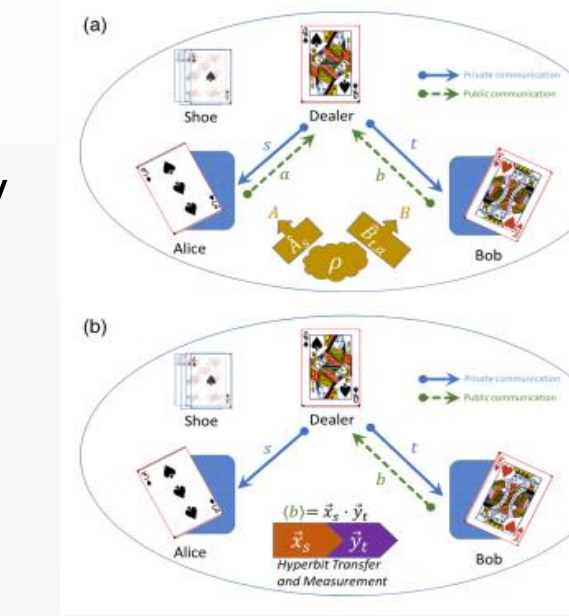
Personal Methodology



Previous Results

Expected Results:

- Shown correlation between classical and quantum versions of games shown by Eisert et al. 1999
- Quantum advantages only apply in a specific set of cases but can be used to reap an advantage in the real world, as shown by Lin et. al. 2020.



[Lin et al. 2020]

[Eisert et al. 1999]

Expected Results

Expected Results: Answer the hypothesis in a supportive way and show explicitly how to solve the question of how quantum mechanics can support or provide aid to communication in ways that were not classically possible, and even to find that such a protocol exists, as there is always a possibility that it does not.

Conclusion

Conclusion:

The expected results of this proposed research would ideally be the enhancement of communications that are classically restricted. The graphs above show the odds of winning classically with different scenarios, and then the odds of winning given a quantum enhanced advantage

Application:

This could have very large impacts on many communication networks around the globe. The fact that it allows very fast communication could help replace fiber optic cables (reducing cost of clearing cable runs), instantaneous communication through shared past and no "communication scenarios," transglobal communication, even interstellar communication through Bell tests and Casino Game type situations

Future Research

Future Focus and Research:

Finalize the quantum casino game and develop the checklist that will be used to identify scenarios that may profit from quantum advantages. We then plan to identify a general class of real-world scenarios to aid in possible implementations of quantum communication systems

Acknowledgments

I would like to thank my Science Research teacher Ms. Rinaldo, for her support and understanding through this project. A special thanks to my parents and peers for sitting through my convoluted explanations. And most importantly, I would like to thank my mentor, Mr. Rodrigo Cortiñas for helping me immensely throughout the year-explaining complex topics, recommending recourses, and proofreading and editing my work. I am very, very grateful for his guidance.

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