# Demonstrating the Effects of Decoherence on Quantum Computers

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My project aimed to investigate the effect circuit complexity has on levels of decoherence in quantum computing algorithms. I also wanted to demonstrate that higher degrees of entanglement in a quantum system lead to especially high error rates. I hypothesized that quantum algorithms with higher circuit complexity would experience greater decoherence and that systems with entangled qubits would exhibit especially high noise levels. I tested 21 different circuits (G2-G22), each for 9 trials, and each trial I ran for 1,024 shots. I also ran a preliminary trial (G1) to determine my independent variables like the QPU I would use and which registers had the highest accuracy (I settled on ibm_brisbane and q[63]). I first ran 4 different types of circuits: deterministic and probabilistic for 1 qubit and deterministic and probabilistic for 2 qubits. I saw the greatest effect of circuit complexity on decoherence in circuits G9-G11. While G9 maintained an accuracy of ~95%, G11 struggled to reach 85% due to increased complexity. I then ran an additional 8 tests (G15-G22), solely focusing on what impact the degree of a simple GHZ state has on the accuracy of the results. While 1-4 qubits comfortably managed accuracy rates at or above 90%, the levels of decoherence significantly increased with qubits 5/6 (~60% and ~30% accuracy, respectively), and by qubits 7/8, the data was unrecognizable from the expected output. These results concur with my hypothesis that higher circuit complexity and increased entangled states lead to higher decoherence levels.

**Awards Won:**