

# Von Neumann, Mathematics, and World War

## II

Sheela Ahmed

December 16th, 2015

### **1 Introduction**

Born in Budapest, Hungary on December 28, 1903, John Von Neumann (Figure 1) became one of mathematics greatest and most clever minds. He combined theories and ideas from various subjects, including Mathematics, Physics, Economics and Computing. He is known as a prime representative of twentieth century science, with his accomplishments in Game Theory and his involvement during WWII.

Von Neumann grew up surrounding himself with mathematics and problem solving. He grew up receiving full education and attending one of the best establishments in Budapest, Lutheran Gymnasium [1]. It wasn't until the 1920s that Von Neumann made his trip to America, where he further

pursued his research and discoveries in the field of mathematics and science.



Figure 1: John Von Neumann in his thirties.

## **2 World War II and the Manhattan Project**

In the late 1920s, Von Neumann became a guest professor at Princeton University, aiming to improve the level of education taught to students. Of course, this was around the time of the Stock Market Crash in 1929. Being a Jew and from Hungary, Von Neumann was lucky to have escaped the persecution that was beginning in Europe and come to America, since the events of the second World War were starting to creep up. Once he received U.S. citizenship in 1937, John Von Neumann was asked to collaborate with the government and work in laboratories to conduct research to create weapons that could be used in defense during the time of the war. As technology

was newly becoming available, scientists were in high demand to create new weaponry and advance the government's armed forces against any enemies. Von Neumann's main objective, at this point, was to create the world's most powerful bomb as quickly as possible, and he became a part of the Manhattan Project [2]. After years of research, John Von Neumann, along with a few other physicists and mathematicians created what was called the H-bomb. The H-bomb was set to be a thousand times more destructive than the atom bomb that dropped at Hiroshima in Japan, which was equivalent to 13 kilotons of TNT.

Von Neumann's main contribution to this project was to design the explosive lenses required to constrict the plutonium core of the weapon. He had also discovered that the angle at which the bomb would be dropped greatly affected its explosive power. An angle of  $90^\circ$  or less would provide greater power than directly above a target [1].

### **3 Quantum Mechanics**

Although Von Neumann is mostly known as a mathematician, he applied his theories and ideas to numerous areas of physics and computers, which shows his importance in the Manhattan Project. But Von Neumann became the first person to thoroughly lay a foundation in quantum mechanics. His most famous equation is known as the uncertainty equation, which essentially is an inequality that can assume physical properties of a particle at certain

positions [3]. The equation is

$$\sigma_x \sigma_p \geq \frac{h}{2}$$

where  $\sigma_x$  and  $\sigma_p$  refer to the position of the particle and  $h$  is the reduced Planck constant,  $\frac{h}{2\pi}$ . Von Neumann discovery led to a continuing approach towards more knowledge in the field of quantum mechanics and the use of mathematics in physics.

## 4 Game Theory

As John Von Neumann continued his research in mathematics and science, he became very intrigued by the game strategy. He had previously created the minimax theorem, which stated that in games with "perfect information", players can minimize their maximum losses. Von Neumann talks more about this in his 1944 book, *Theory of Games and Economic Behavior* [3]. He also founded the method of a proof, backward induction, which is used heavily in game theory nowadays. Von Neumann had paired with Oskar Morgenstern, a German mathematician, to create the entire concept of game theorem and how it applied to the field of economics [1]. After Von Neumann's death, the concept of game theory went on and elaborated on Von Neumann and Morgenstern's ideas.

## 5 Conclusion

The main thing that separated John Von Neumann apart from other known mathematicians was his applications to other field of study. He connected his mathematical ideas and knowledge to physics, computing, economics, game theory and engineering. He had grown up with a lot of interest in mathematics and showed his passion when becoming involved with the Manhattan Project. Up until his death in 1957, John Von Neumann continued his research in mathematics to find new ideas and theories in numerous other subjects and forwarded a large amount of knowledge to other mathematicians, scientists and researchers.

## 6 References

1. Israel, Giorgio and Ana Millan Gasea. *The World As A Mathematical Game*. Science Networks. *Birkenhhauser*. Boston. 2009.
2. Macrae, Norman. *John Von Neumann*. Pantheon Books. New York. 1992.
3. Von Neumann, John. *Theory of Games and Economic Behavior*. Princeton University Press. 1944.
4. Werner Heisenberg, *The Physical Principles of the Quantum Theory*, p. 20.