On Quantum Mechanics and Free-Will

By

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Abstract

Prior to the advent of quantum mechanics in the 20th century, the world was thought to exist entirely based on mechanistic principles, which were described by Newton's laws. The possibility that the world was not entirely deterministic was suggested when very small particles were found to behave in a manner that could not be described by Newtonian mechanics. Electrons, photons, atoms, and similar small particles have been found to behave in an apparently random manner. There is no room for true randomness and true determinism to coexist. The free-will doctrine has always been debated within the Church, but the debate was expanded to include evidence from the scientific community with the discovery and exploration of quantum mechanics. The possibility of a relationship between quantum indeterminism and free-will will be discussed. The first objective of this project is to explore the possibility of an interaction between quantum mechanics and free-will. The second objective of this project is to gain useful information regarding the relationship between science and religion.

Introduction

Quantum mechanics and free-will each have some fascinating properties as independent fields of study. However, this paper is primarily concerned with discussion of a possible interaction between the two subjects.

Determinism is essentially the belief that the entire universe and all of its members have been predestined to a certain course of events, from beginning to end. Newtonian mechanics based on Aristotelian ideals directly implied a deterministic universe. A universe that operated according to a strict set of laws could easily fit in with the idea that the universe was operating according to a master plan, which had already been laid out and set in motion.

Quantum mechanics has a mathematical basis. However, the intent of this paper is to present a survey of the field. This presentation of quantum mechanics will center on the apparent randomness in the behavior of small particles, which has been shown to have effects in the macroscopic world (Engel et al. 2007).

This discussion will primarily be concerned with predestination and free-will as it relates to theology and how these doctrines may relate to the science of quantum mechanics. The question of whether or not humans possess free-will is being studied and examined closely by neurologists, psychologists, physicists, philosophers, and countless others, who seek to determine how humans make decisions or if humans even have the capacity to make choices. It has been suggested that choice is actually an illusion created by the mind and that there is no such thing as free choice (Molé 2004).

Predestination is a popular topic for discussion among most world religions. According to Valea (2007), 'karma', 'destiny', 'fate', and 'predestination' are used interchangeably as theologians attempt to make sense of the paradox of freedom and causality. Many people in the world today are concerned about their futures. Are we moving like robots on the face of the earth? Or do we have control of our own destinies through our choices?

Discussion

Introduction to Quantum Mechanics

Quantum mechanics is the study of the behavior of very small particles (e.g. photons, electrons, and quarks). The science of quantum mechanics has shown that the classical view of motion described by Newtonian mechanics was lacking for very small objects. Newtonian mechanics are essentially correct for the macroscopic world, but at some size level between

humans and electrons, this description breaks down. Laws accepted for several hundred years were found to be lacking when describing the motion of very small particles (Gribbin 1984).

Initially, the motion of small particles was described in terms of a wave function (Equation 1, Taylor, Hooks, and Summons n.d.).

$$\frac{\partial^2 \varphi}{\partial x^2} + \frac{8\pi^2 m}{h^2}(E - V)\varphi = 0 \qquad \text{(Equation 1)}$$

Equation 1: m = second derivative with respect to X, φ = Schrödinger wave function, E = energy, V = potential energy, x^2 = position.

Equation 1 is the most familiar description of wave mechanics, and provides a good approximation. The waves in Schrödinger's equation are probability waves. This probability is more like a tendency for something, in between possibility and reality. Thus, equation 1 has been found lacking (Heisenberg 1958). This probability function is its own sort of strange reality, in many-dimensional space.

Heisenberg's (1958) uncertainty principle states it is impossible to know both the exact position and momentum of an electron. As the precision of one measurement increases, the precision of the other measurement decreases, so that theoretically if one measurement is infinitely precise, the other, by definition, has infinite imprecision. Usually, some general information about the location of the electron, and some general information about its momentum are acquired, with neither measurement being overly precise. The electron has a probability wave associated with it, describing the most probable location of the electron. Its exact position cannot be known. However, there is an area of high probability for electron distribution, which correlates approximately to electron orbitals. Nevertheless, the probability of finding an electron at any point in the universe never actually diminishes to zero. Illustrating the

uncertainty principle, an electron that is at one moment around the nucleus of an atom may just show up in your television set, or on Mars, or anywhere else in the universe, although the probability is very, very small (Gribbin 1984).

The motion of small particles does seem to be completely random, when they are not influenced by an observer. Experiments such as the double-slit experiment (Figure 1) have shown that observation of particles affects the results of the experiment (Gribbin 1984).

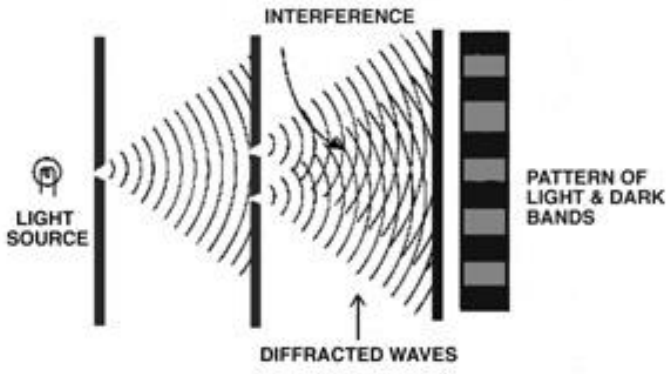

Figure 1: The double-slit experimental setup (far left - source; middle - wall with two holes; far right – detector)
Source: http://www.thekeyboard.org.uk/Quantum%20mechanics.htm

The double-slit experiment may be conducted using an electron or light source. A plate positioned opposite the double-slit records the results (i.e. the location a given particle strikes). As these strikes build up, two types of patterns are expected. The two patterns are not a wave or a particle, but one pattern exhibits wave-like characteristics (Figure 2), and the other exhibits particle or discrete characteristics (Figure 3).

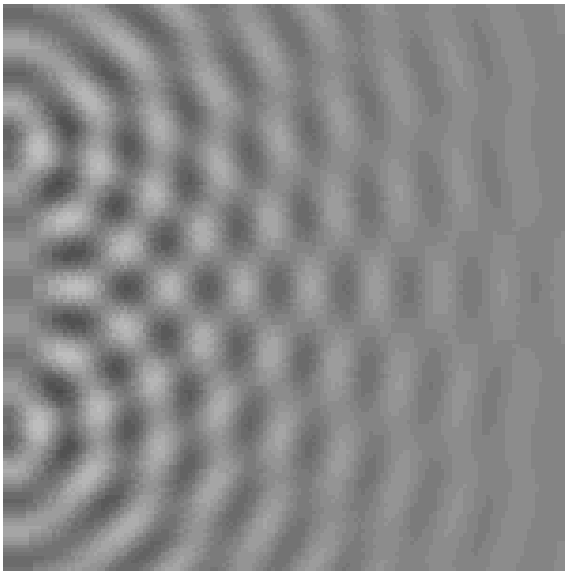

Figure 2: Liquid Wave Interference (light areas – crests; dark areas – troughs)
Source: http://www.colorado.edu/physics/2000/schroedinger/index.html

The results of Figure 3 indicate that electrons behave like waves. Electrons have always been thought of as very tiny particles, but particles nonetheless. As the experiment continues, if one slit is covered, the pattern that forms is no longer a wave pattern, but more like a conglomerate of electrons (Figure 4).

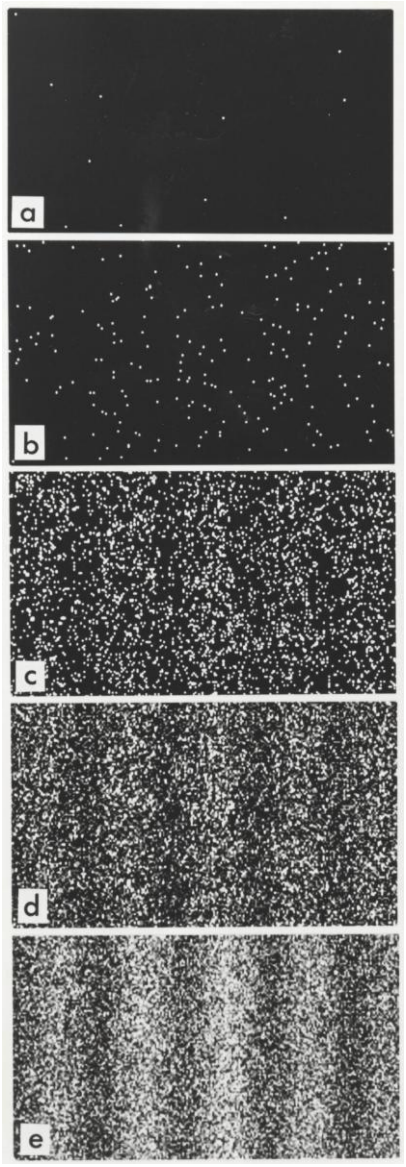

Figure 3: Interference pattern created over time when both slits are open
Source: http://upload.wikimedia.org/wikipedia/commons/7/7e/Double-slit_experiment_results_Tanamura_2.jpg

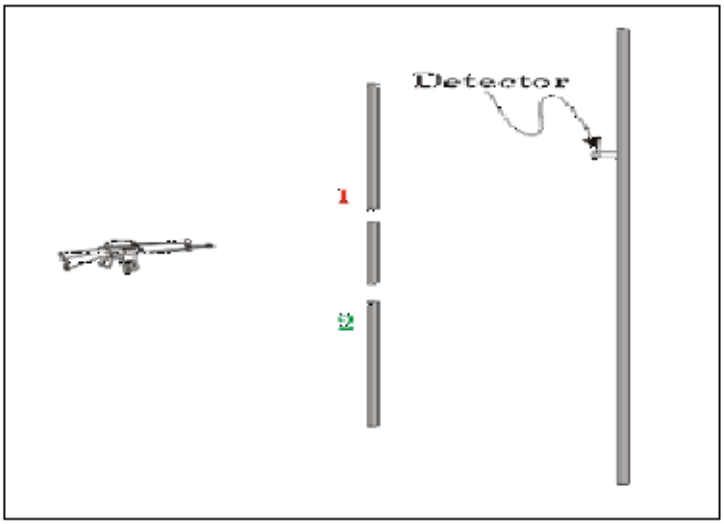

Figure 4: Electron Behavior as Particles
Source: http://www.upscale.utoronto.ca/GeneralInterest/Harrison/DoubleSlit/DoubleSlit.html

Thus, when the slit is covered, the electrons behave like particles. Additionally, if an observer is watching the experiment, the electrons behave as particles, whether one or both slits are open. Not only is there the appearance of knowing if one of the slits is covered, the electron also appears to have knowledge of being watched. An observer who is attempting to record the results seems to affect the behavior of the particles in the experiment. Without being directly observed and both slits left open, a wave interference pattern is produced again.

In a manner of speaking, the electron prefers to travel as a wave, in a spread-out fashion, which by extension could mean that it has not yet "chosen" a path to follow. When we observe the electron and attempt to determine which slit it has traveled through, the wave function is said to have collapsed and the electrons behave like particles. The electrons must select either one, but not both, of the slits to travel through. When the observer is removed, the electron seems to travel through not just one, but both slits, as a wave. Instead of choosing one path, the electron seems to take all the paths. It travels down all the possible paths until it is forced, by an

observer, to make that choice. Yet, the choice has the appearance of randomness. The wave function apparently collapses. What does observation do to the electron to apparently change its behavior? When the electron is not being observed, it behaves as a wave and when it is being observed, it behaves as a particle. How can it be both? How does it even know when it is being observed? How does it select which path to take?

The seemingly random behavior of these tiny particles was unsettling to the scientists who faithfully adhered to Newtonian mechanics, which was the accepted description of the world. There was no room in a mechanistic description for randomness of this level. Events that seemed random would in fact be contained within a causal chain, even if humans could not know the causative agent which set the event in motion. A truly mechanical universe would operate according to a predetermined master plan, with each event connected to previous events. It had been assumed that the world works in exactly the same manner, regardless of whether there is someone there to observe. The proverbial tree in the forest makes a noise when it falls, regardless of whether or not there is someone there to hear it. Yet, the data has led to the conclusion that perhaps nothing assumed to be real actually is real. Prior to observation or measurement, the location of an electron seems to be described by a probability wave rather than an exact point in a coordinate system. The act of describing the position of the electron seems to affect the location by collapsing the wave function, causing the electron to behave like a particle, with a definite position, as has already been discussed. Niels Bohr, a prominent Danish physicist who worked extensively on the development of quantum theory, once said, “Nothing is real, unless it is observed.” (Davies 1983) This is disturbing to scientists for obvious reasons. If nothing is real unless it was observed, then has mechanics met its end?

Electrons seem to move in no organized fashion, and might quite suddenly move from close proximity to the atomic nucleus to some far off place with no apparent reason (Gribbin 1984). This possibility of randomness changed the scientific perspective on determinism. It was previously thought that the position and momentum of every particle in the universe could be known, if only the capabilities existed to make all the measurements. Laplace (1814) once said,

> We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at any given moment knew all the forces that animate nature and the mutual positions of the beings that compose it, if this intellect were vast enough to submit the data to analysis, could condense into a single formula the movement of the greatest bodies of the universe and that of the lightest atom; for such an intellect nothing could be uncertain and the future just like the past would be present before its eyes.

However, with the introduction of randomness, and the knowledge that the exact position and momentum of a particle cannot be known simultaneously, scientists have begun to believe that perhaps deterministic interpretations are incorrect. If the exact position and momentum of a particle cannot be known, then it cannot be said that we live in a deterministic universe. It is important to note that these measurements are not being made due to a deficiency in the experimental procedures. Gribbin (1984) states,

> It is a cardinal rule of quantum mechanics that *in principle* it is impossible to measure precisely certain pairs of properties, including position/momentum, simultaneously. There is no absolute truth at the quantum level.

Newtonian mechanics only allows for a deterministic universe in which everything is predetermined and works according to an exact mechanistic description. When Newton's laws were found to be lacking in their description of the behavior of very small particles, a new perspective on how the universe works was needed. Perhaps the fate of each electron is not predetermined. Perhaps the future of an electron cannot be known, or, as will be suggested later, does not even exist until the electron is affected by some outside act.

As facets of quantum theory were uncovered, different physicists tried different experiments, real and imagined, in order to attempt to make sense of the radical new approach to the world (Gribbin 1984). Erwin Schrödinger was upset at the implications of this new science. As quantum theory developed, its increasing weirdness reportedly provoked Einstein to say, "God does not play dice" (Davies 1983). Yet, according to the predictions of quantum mechanics, it appeared that perhaps he did play dice after all. Schrödinger understood Einstein's sentiment and concurred with it. To emphasize the absurdity of an electron which exists in multiple states as was indicated by the double-slit experiment, Schrödinger devised a "thought experiment" involving a cat, the famous paradox of Schrödinger's cat (Gribbin 1984). In this experiment, a cat was put into a box, along with a vial of poison, and a bit of radioactive material. An apparatus was set up inside the box so that if a radioactive particle decayed and emitted an alpha particle, it would trigger a switch and the vial of poison would be broken, killing the cat. According to quantum mechanics, the decay event might occur, or it might not. The decay event would be spontaneous and completely random. There would be no way to know what had happened to the cat unless we looked inside the box, yet as has been seen, the act of observing apparently interferes with the results of the experiment. Quantum mechanics says

that the cat exists in a "superposition of states" – in other words, the cat is neither alive nor dead, yet it is alive and dead at the same time. The decay event has both occurred and not occurred. The only way in which we can force the situation to become a reality is by looking into the box. At the time we look into the box, it may be determined decisively whether the cat is alive or dead, but until we do, it exists in both. Neither is a reality, yet both are. Reality does not exist unless we observe it. By observing the cat, we collapse its wave function, just as the wave function of the electron was collapsed in the double-slit experiment. The electron exists as a wave, with several possibilities available to it, until it is observed and the wave function is collapsed, and the electron is forced to choose one path above the others. The cat inside the box exists in several possibilities until the box is opened and one possibility occurs against the others. This idea was repulsive to many scientists at the time, and many still struggle with it. After all, if the choice of which future will be adopted upon observation is truly random, then perhaps humanity is in the same state.

According to Newtonian mechanics, the universe is completely deterministic, which means that each human is living in the only state possible. There are no alternate futures available, for electrons, humans, or anything in between. Each particle had its own function and path which could not and would never vary. But, according to the "new physics", we see that there seem to be multiple futures available to these very small particles, and that they seem to exist in all of the possible states until they are forced to choose one.

Newtonian mechanics has been found to give a fairly accurate description of the macroscopic world. Where does quantum theory give way to Newton's laws? Where does the connection lie? It has been suggested by some (Schrödinger 1992; Miller 2007) that the

connection lies within the genes. A gene contains a relatively small number of atoms, yet it exhibits remarkable permanence (Schrödinger 1992). This can only be explained by the presence of molecules, which are kept in a reasonably orderly state by bonds between atoms. Chemistry had a good knowledge of these bonds, but not much understanding until the 20th century, and the advent of quantum mechanics. The science of inheritance may be dependent upon quantum theory for its explanation. At the time Schrödinger gave his lectures not much was known about the gene, much less about mutations. It is now known that mutations do not occur at random in the genome (Stearns & Hoekstra 2005). However, most of this is due to protective mechanisms preventing permanent mutations, and changes in the DNA sequence still occur quite randomly.

An understanding of this apparent randomness may come from quantum mechanics. At the level of very small particles, only certain energy levels are available to these particles. An atom may make a 'quantum jump' from one energy level to another, but it cannot be between the two levels. To move from a lower level to a higher level, there must be some energy input, and to move from a higher level to a lower lever, some energy releases. In a molecule, energy input leads to a different configuration of the molecule, where the atoms are arranged differently than before. In biology, the different arrangement is an 'allele' in the same location as before. The quantum jump can be seen as the mutation. These different arrangements form different isomers of a molecule based on the discrete energy levels at which each isomer exists. Because the isomers differ, they will have different physical properties from each other. Yet, each is stable in its own conformation. Energy is required to change isomer 1 into the configuration of isomer 2. Yet, once isomer 2 is formed, it exists in its own state. The biological application is that when a

change in the gene occurs it requires a certain amount of change in the environment (energy), but once it occurs, it is in place. Quantum mechanics has done much to help explain mutations, and biologists (Miller 2007) believe that the genes are the crucial link between the quantum world and the macroscopic, living world.

Quantum mechanics has revealed some strange paradoxes in the world. Nothing is real unless it is observed. The observer forces what is being observed to choose a "future," but until that occurs, multiple possibilities exist. The object seems to exist equally in all the possibilities until the crucial moment of choice. Strong ties between quantum mechanics and biology have been suggested (Schrödinger 1992), through the mechanisms of inheritance and genetic variance.

Free-Will Doctrines of the Church

The doctrine of predestination has long been debated inside and outside of the Church. There are two schools of thought on the issue. One group believes primarily in predestination as the way in which Christians are called to salvation. The other asserts that we are endowed with free-will, and must choose to come to God for salvation. This has been a hotly debated discussion topic in the church since the time of St. Augustine. St. Augustine himself espoused the doctrine of predestination, but not until after some deep deliberation and study on the subject. At one time, Augustine believed in the freedom of the will (Portalié 1907). However, after a confrontation with the monk Pelagius, and a subsequent condemnation of Pelagianism, his writings are filled with predestination theology. He admits that his error in believing in free-will arose from perceiving the grace of God as something other than the free and undeserved gift of God (St. Augustine – On the Predestination of Saints n.d.). Through the testimony of another, who reminded Augustine that none could come to God had it not been for the undeserved gift of

grace, Augustine changed his mind on the doctrine of predestination, giving some explanation in a letter to Prosper and Hilary ca. A.D. 428,

> ...I myself also was convinced when I was in a similar error, thinking that faith whereby we believe on God is not God's gift, but that it is in us from ourselves, and that by it we obtain the gifts of God, whereby we may live temperately and righteously and piously in this world. For I did not think that faith was preceded by God's grace, so that by its means would be given to us what we might profitably ask, except that we could not believe if the proclamation of the truth did not precede; but that we should consent when the gospel was preached to us I thought was our own doing, and came to us from ourselves. (St. Augustine – On the Predestination of Saints n.d.)

Augustine continues on his letter and mentions that not only did he have to change his thinking on predestination; he had to change some of the writings that he had compiled and distributed to his congregation and others, and had to take a different position on predestination than he had previously believed to be true.

It may be seen that the doctrine of predestination has been the subject of many conversations and diligent studies. For many years, teachers and theologians have searched for the answer to this question. Some believe the answer is not predestination at all, but freedom of the will. There are many facets to each of these doctrines, and many interpretations on the existence of each. Some say that those who espouse predestination leave no room for a truly loving relationship with God, while others say that the proponents of free-will are limiting the

power of God while assigning too much power to humanity. To gain a greater understanding of each side of the argument requires a closer look at each one.

Determinism is the idea that every person or thing on the earth is simply operating in the path in which it was destined to operate, from the beginning of time. All the choices made by men and women are not really choices; instead, they are illusions of choice, and the choice has already been made for them. God has predestined to that person every action that he or she will make during the course of his or her entire lifetime. The outcome of every situation was already in existence, but due to humanity's one-dimensional perception of time, it simply could not be seen from the human perspective. Were it possible to step outside of time, like God, it would also be possible to see the outcome of every event, with no possibility for variation. The implication is that humans have no choice as to how they want to live. It has already been planned. Making a choice that will affect the future is not even a possibility.

From a predestination standpoint, each member of the elect is called by God to salvation, and the result has already been predestined. There are several Scriptures from the Bible that lend themselves to a predestination standpoint.

> For those whom he foreknew he also predestined to be conformed to the image of his Son, in order that he might be the firstborn among many brothers. (Romans 8:29, English Standard Version)

> According as he hath chosen us in him before the foundation of the world, that we should be holy and without blame before him in love: Having predestinated us unto the adoption of children by Jesus Christ to himself, according to the good pleasure of his will… (Eph. 1:4-5)

According to these Scriptures, it would seem that God has predestined the elect since the foundation of the world. However, predestination and foreknowledge may be distinguished as two separate beliefs, which may mean the implication of these verses is not deterministic, but instead has to do with the fact that God is omniscient and knows what will happen before it happens (Bucher n.d.). Each one that is called will be saved; each one that is not called will be lost eternally.

In opposition, free-will says that humans have, at least, some degree of control over their own futures. There are many interpretations of free-will. Compatibilism states that determinism and free-will are compatible with each other. Incompatibilism, on the other hand, insists that free-will and determinism cannot coexist (Ginet 1983). Hard determinism is a version of incompatibilism which completely rejects any version of free-will in favor of determinism (Koons n.d.). Metaphysical libertarianism rejects compatibilism, but in favor of free-will over determinism (Strawson 1998/2004).

In theological circles, most people generally identify with Calvinism or Arminianism. Calvinism, as it is traditionally interpreted today, believes in the unconditional election of the saints to salvation. God has chosen those who will be saved from the foundation of the world, and his choice of the elect is independent of any act of man. Once a person is called by the grace

of God to salvation, that person cannot resist the call of God. Calvinists also believe in double predestination – saints are predestined to heaven, and sinners are predestined to hell. John Calvin did not heavily emphasize the doctrine of predestination. However, Calvinism has evolved over the years to represent the opinions of those who believe in predestination without human free-will (Xenos Christian Fellowship 2007).

Arminianism says that while God is sovereign over humanity, his call to salvation is extended to all. Christ died for the entire human race, and salvation is a free gift from God which only requires faith to receive the gift. The call to salvation may be rejected, but grace is extended equally to all. Humans are responsible for making their own decision to come to salvation, but it is God who gives salvation (Xenos Christian Fellowship 2007).

It is apparent that there are many thoughts on free-will and predestination. Each person has his or her own perceptions of how the will, the mind, and God interact. Even for non-Christians, the subject of human free-will is of interest, but for Christian scholars and believers, it is even more important. The questions of free-will and predestination are tied primarily to the subject of how men are able to come to God for salvation. From the free-will perspective, each human being has the call of God on his or her life to salvation. It is up to each person to choose whether he or she will accept God's offer of salvation. Many who believe this cite the Scripture from the New Testament in which Jesus says, speaking of the little children who came to him,

> …and it is not the will of my Father who is in heaven that one of these little ones should perish. (Matt. 13:14)

From this Scripture, it seems to be apparent that God desires that everyone come to him to receive salvation, and that all people have the call of God on their lives to salvation. Advocates

of free-will argue that a God who loves all humans equally, as the Bible says, would want to give every person the opportunity to accept salvation. It is hard to imagine that God would predestine only a certain number of people to be saved, and forsake the rest of humanity.

Proponents of free-will also use Scriptures that speak of God changing his mind to support their position. In the Old Testament account of Abraham interceding for the city of Sodom, God appears to change his mind numerous times as Abraham pleads for mercy on behalf of a certain number of righteous men.

> So the men turned from there and went toward Sodom, but Abraham still stood before the LORD. Then Abraham drew near and said, "Will you indeed sweep away the righteous with the wicked? Suppose there are fifty righteous within the city. Will you then sweep away the place and not spare it for the fifty righteous who are in it? Far be it from you to do such a thing, to put the righteous to death with the wicked, so that the righteous fare as the wicked! Far be that from you! Shall not the Judge of all the earth do what is just?" And the LORD said, "If I find at Sodom fifty righteous in the city, I will spare the whole place for their sake." Abraham answered and said, "Behold, I have undertaken to speak to the Lord, I who am but dust and ashes. Suppose five of the fifty righteous are lacking. Will you destroy the whole city for lack of five?" And he said, "I will not destroy it if I find forty-five there." Again he spoke to him and said, "Suppose forty are found there." He answered, "For the sake of forty I will not do it." Then he said, "Oh let not the Lord be angry, and I will speak. Suppose thirty are found there." He answered, "I will not do it, if I find thirty there." He said, "Behold, I have undertaken to speak the Lord. Suppose twenty are found there." He answered, "For the sake of twenty I will not destroy it." Then he said, "Oh let not the Lord be angry, and I will speak again but this once. Suppose ten are found there." He answered, "For the sake of ten I will not destroy it." And the LORD went his way, when he had finished speaking to Abraham, and Abraham returned to his place. (Genesis 18:22-33)

As Abraham prays, he prays for the cities to be spared on behalf of an ever-lower number of righteous men, and each time God agrees. This passage suggests that God had an original plan, but through Abraham's intercession, he changed his mind and would spare the city based on the number of righteous inhabitants within the city.

Another Scripture which would infer the possibility of God changing his mind comes from the New Testament,

> Therefore, confess your sins to one another and pray for one another, that you may be healed. The prayer of a righteous person has great power as it is working. (James 5:16)

If unconditional predestination ruled the course of the future, then the prayers of believers would seem to have no real effect on the course of human events. It would be unnecessary to pray for God's intervention, because the predestination doctrine suggests that the future is already determined without exception. By changing his mind, God would alter the future, because it would be a deviation from the previously determined course of action, and this in incompatible with predestination.

Nearly all Christians believe that God has foreknowledge of the events that are going to happen. However, beyond that there is some argument between those who believe in predestination and those who believe free-will. The supporters of predestination believe that God's foreknowledge is the equivalent of foreordination. If God knows that something will happen, then it is a decree that the event will take place. Those who believe in free-will say that God's foreknowledge is not a decree of future events; instead, it is just what the term implies – prior knowledge of an event that has not taken place yet in history. We can have foreknowledge that an event is going to take place and even how it is going to turn out, but that does not mean that we affect the outcome. Foreknowledge of how the Civil War would turn out, with the North defeating the South, would not actually affect how the war would turn out. However, it must

also be said that we cannot pretend to comprehend God's mind. If God could truly be understood, then he would cease to be God.

> For my thoughts are not your thoughts, neither your ways my ways, declares the LORD. For as the heavens are higher than the earth, so are my ways higher than your ways and my thoughts than your thoughts. (Is. 55:8-9)

God's perspective on time is undeniably different than our own. God is outside of time, so time is irrelevant to God. Human history, which we see as a unidirectional vector, may be seen by God as a line. Every event that has taken place, is currently taking place and will take place is not necessarily seen in sequential order; instead, all events are occurring simultaneously.

This observation may be interpreted in two ways (Bratcher 2006). First, one may choose to believe that God sees not only all events in time, but also all possible events. This interpretation allows for free-will because the events that actually took place would occur as a result of human choice. The second interpretation is that God does indeed see all the events of human history exactly as they have happened or are going to happen. This is favored by those who believe in predestination because by seeing all the events of history as they are going to occur, it does not seem as if there is much room for free-will or the opportunity to choose your path. Essentially, the path is already laid out for each person.

Conclusion

As has been seen previously, quantum mechanics seems to indicate randomness within nature, in direct opposition to the deterministic universe presented by Newtonian mechanics. Events that are truly random can be said to occur due to free-will. Electrons "choose" which hole to go through in the double-slit experiment, and there is no reason for them to choose one

hole over another; they simply do. If both holes are open, the electron declines to choose and seems to go through both holes, like a wave. But, when forced to choose, either by an observer or when one of the holes is closed, the electron selects its path accordingly (Gribbin 1984).

So, what does this mean for humans? Does it mean that there are multiple futures available to humans? This question has been extended so far as to suggest that there are multiple universes, each containing a different possible outcome. When a human being makes a choice, that person puts himself into a path for his future. Is it even possible to know if multiple futures exist? How do we exist as we do? Are we like electrons, making choices which shape our futures but having multiple possibilities available to us? If nothing is real unless it is observed, what makes us real? Is there some observer (God) which collapses the wave function of the entire universe? If God is the observer and collapses the wave function of the universe and our lives, do we have completely free choice about our futures, or do we have no choice at all?

There are several points which lend themselves to the free-will standpoint. Moral responsibility is directly connected to the free-will argument. How can a person be blamed for committing a crime that the person was predestined to commit? Yet criminals are convicted daily for crimes against humanity, and defense attorneys do not attempt to plead "fate."

Free-will advocates also question the effectiveness of missions if each person has been predestined to salvation or condemnation according to God's sovereign will. The "elect" have been predestined to salvation and will be saved forever. If that is the case, then it may be argued that missionaries and the money that goes to support them is a waste because according to a strict predestination interpretation, the elect will be saved independent of human effort.

If humans have free-will, then we must choose our paths independent of a causal chain of thoughts or events. However, is true free-will even a possibility? Molé (2004) states that,

> ...[the existence of free-will] is entirely dependent on the possibility of "uncaused causes". That is, if we are honestly to consider ourselves free, then we ourselves must be the only cause of our actions. We must be able to demonstrate that we do not act the way we do because prior events compelled us.

Even if quantum mechanics allowed for the existence of free-will, perhaps we are not truly capable of free choice. Does true freedom of choice require existence independent of a causal agent? Even though we may imagine that we are acting independent of a causal chain of events when we make a choice, unknown factors may actually influence the decision. Molé (2004) suggests that,

> The military generals in Tolstoy's epic imagine they are controlling the fates of entire armies and even nations, but countless historical contingencies they are unable or unwilling to consider rigidly determine their every action. What it all comes down to, as philosophers from Friedrich Nietzsche to Galen Strawson have argued, is that we cannot be a *causa sui*, or the ultimate cause of ourselves. We had no say in the forces that produced us, and so we cannot be free in any ultimate sense of the word.

Does this, in turn, lend itself to the predestination argument? If humanity cannot loosen the grips of causality, then perhaps God is the primary causative agent. Perhaps the first event on the human timeline was set into motion by him long ago, and the world has since been running like clockwork. We have the illusion of free choice, but perhaps it does not exist after

all. Benjamin Libet, in the 1980's, performed an experiment in an attempt to determine whether or not humans have free-will. In the experiment, Libet asked the participant to decide to flick their wrist at a random moment, while he measured the activity of the brain at that time. In the experiment, Libet found that brain activity was recorded about a half second before the participant decided to move; in other words, the conscious choice on the part of the participant was made after the unconscious choice in the brain. However, some scientists believe that Libet had insufficient evidence to support his conclusions, based on neuronal firing patterns (Pollen 2006). Nevertheless, it is interesting to note that the brain activity preceding a hand motion was recorded up to half a second prior to the participant making a conscious choice to move the hand.

Rene Descartes suggested that the brain chooses one of multiple possibilities and then causes the body to perform the desired action. A relation between preparation of action in the brain and free-will has long been sought, but this mind-body dualist philosophy is incompatible with modern neuroscience. In fact, neurology seems to suggest that consciousness is a result of the activity of the brain, rather than causation (Haggard 2005). Instead of conscious choice stimulating brain activity, then translating into other activity, brain activity seems to dictate our choices. Thus, the question is asked: what causes the initial brain activity? Are brains designed to make choices unconsciously? If so, does this really lend itself to a true free-will interpretation?

One of the required elements for drawing a comparison between quantum mechanics and free-will is finding where the microscopic world and the macroscopic world interact. Ordinary observable objects do not exhibit quantum properties, and it is generally accepted that this is due to the thermal energy produced by large numbers of atoms. In an average (70 kg) human body,

there are roughly 7×10^{27} atoms (Kross n.d.). The thermal energy (heat) of these atoms moving and interacting with each other obscures their quantum behavior (Corbitt et al. 2007). This is why quantum fluctuations are not seen in the macroscopic world; instead, the behavior of large objects is governed by Newton's laws.

There is some promising research in the area of quantum behavior of large objects. New techniques, especially laser cooling, are being used to cool macroscopic objects to nearly absolute zero. Massachusetts Institute of Technology researchers cooled a 1 g mirror to 0.8 K in 2007. Although still not cool enough to obscure thermal activity, the scientists working on the project were hopeful concerning the possibility of cooling the mirror or another object to an even lower temperature. When the atoms in the large object are sufficiently cool, the thermal energy of the atoms would be small enough that quantum behavior might be observable even for large objects (Corbitt et al. 2007). If this experiment were able to be performed, much more could be learned about how the quantum world and the macroscopic world are intertwined. If humans could theoretically arrive at the point where every atom in the body exhibited quantum behavior, would each person behave like an electron behaves in the double-slit experiment, demonstrating a wave-particle duality and randomness? These questions are some key concepts to be explored in more depth.

If the atoms in the body as individual entities display quantum behavior but as a whole collection function according to Newtonian mechanics, then clearly there is a point where one set of rules breaks down and the other takes over. Does this mean that the atoms in the body have free-will, but each human actually does not, displaying emergent properties? Do the atoms

"choose" our destinies for us, causing the brain to register activity before we even make conscious choices?

In the Bible, there are several Scriptures which are used by advocates of both free-will and predestination. Difficult concepts in the Scriptures often seem to be presented in tension-filled pairs; predestination and free-will is one of these pairs. Most Christians believe in God's foreknowledge, as an omniscient God. There is more of an argument over whether God's foreknowledge is actually foreordination; does the fact that God knows that an event is going to happen mean that he also decrees it will happen?

How does quantum mechanics and all its puzzles fit into the debate between predestination and free-will? Does quantum theory lend itself to belief in true human free-will? Is there an absolute truth to be discovered? Questions such as these have been asked repeatedly over the years, and many have struggled endlessly without arriving at a satisfactory conclusion. Perhaps a truly definitive answer does not even exist.

Although there are no ready answers, the conclusion of this project is that humans have, at least, the sensation of free choice. Even if humanity is operating on a predetermined path, and only able to "choose" what has already been chosen, humans are still faced with an apparent choice in most situations. This being the case, it is necessary for humans to live as if each person is responsible for his own destiny. Even if each person has been predestined to a certain fate, the future has not been revealed. Thus, humans should make responsible decisions according to the interpretations they have of the world and their unique circumstances. If free-will truly is an illusion, it is a convincing illusion, and the fact that a feeling of free-will exists translates to responsibility for moral and rational behavior. Science, theology, and personal conviction must

all work together in order for each person to form an individual opinion on difficult subjects such as this. It is interesting to discuss this matter, for the sake of knowledge and understanding, but it is not expected that conclusions will be drawn with absolute certainty from this research.

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