Exploring the existence of free will: A neuroscientific investigation

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Abstract. Free will, an age-old philosophical concept, is integral to our understanding of human autonomy, ethical responsibility, and the legal system. Its presence or absence fundamentally influences our decisions and the fabric of societal norms. In recent years, the advancement of neuroscience has made re-evaluating free will increasingly important. This paper reviews philosophical perspectives from ancient to modern times, integrates neuroscientific experiments, and analyzes psychological research to comprehensively explore the issue of the existence of free will. It enumerates contemporary mainstream views on the existence of free will, discusses the sources of the sense of free will, and highlights its profound implications for both individual and collective societal structures. The paper finds that current discussions on the existence of free will remain controversial. In the end, it summarizes the findings and provides an outlook on future research. New technologies and further interdisciplinary studies are expected to offer new perspectives and evidence for understanding free will.

Keywords: Free will; neuroscience technology; philosophy; libert style experiment; sense.

1. Introduction

Throughout the history of philosophy, philosophers have been engaged with the problem of free will, and they have been trying to solve it. Usually, free will is considered an individual's capacity to make a final choice that is in no way subject to restrictions or pressure from external factors. However, the rise of neuroscience has brought a new scientific angle to this debate. Our growing understanding of the brain's complexity, especially through Libet's experiments and functional magnetic resonance imaging (fMRI) technology, has posed significant challenges to traditional ideas about free will [1].

Libet's experiments indicated that the brain exhibits specific neural activity, namely "readiness potential," even before the individual has an idea about his own decision-making process. This has led to extensive discussions about the true nature of free will [2]. The findings propose that decisions occur milliseconds prior to conscious awareness, hinting that the concept of free will could be illusory. . Additionally, with the fMRI technology, they can detect brain activation patterns related to decisions making that occurred before the actual decision is made, questioning even the more about the traditional views on free will [3]. The existence or absence of free will has deep implications for our concepts of law, morality, and personal responsibility. If free will is merely a subsidiary of neural activity, then it could radically alter our understanding of responsibility and ethics [4].

Additionally, "The Astonishing Hypothesis," by Francis Crick presented the concept of neural determination in accordance with which all behavior and psychological state of a person are only determined by physical characteristics of their nervous system [5]. The concept is derived from the atomic theory of the ancient Greek philosopher Democritus. In the 19th century, Hermann von Helmholtz discovered that nerve impulses are an electrochemical phenomenon, which provides a physical basis for psychological phenomena [6]. In the 20th century, neurodeterminism was concerned and cited by a large number of practitioners of behaviorist psychology.

However, neural determinism has faced opposition from philosophy, psychology, and ethics. For example, compatibility theory holds that neural determinism and free will can coexist. Although people's behavior is restricted by causal laws, they can still make choices based on their desires and true inner tendencies [7]. Traditional dualism, on the other hand, posits that the mind and body are two distinct entities, with the mind potentially free from physical laws, thus providing a basis for free

will [8]. Although various defenses of free will have been proposed, these arguments often have notable weaknesses. For instance, compatibilists aim to show that determinism and free will can coexist but struggle to explain how individuals can make truly free choices in a completely deterministic world [9]. Dualism also faces significant criticism. It has difficult to solve the problem of mind-body interaction—how two fundamentally different entities, the mind and body, can influence each other [10]. Additionally, modern cognitive science research shows that mental processes like memory and emotion are closely tied to the brain's physical states, which challenges dualist perspectives [11]. In summary, while research on free will exists, the exploration of its existence and related issues remains limited and incomplete. The debate over free will still demands further investigation and discussion.

Therefore, in order to delve deeper into the study of free will, this article will analyze the origin and role of individual will, combine Libet's style experiments, and discussions on the concept of free will by philosophers and neuroscientists, comprehensively analyze free will, and evaluate its research challenges. the purpose of this paper is to integrate new findings from neuroscience to thoroughly investigate the existence of free will, the origins of the sense of individual free will, and its functions. Additionally, it will explore whether individuals still have reasons to believe in free will in the face of numerous scientific experimental results challenging traditional theories of free will. This article will first explore the philosophical background and neuroscience concepts of free will. Next, this work delves into key experiments and conclusions on free will in neuroscience. Finally, the conclusions and the challenges and directions of future research are presented.

2. Philosophical background of free will

On the topic of free will, philosophers have discussed it for centuries with an endless range of opinions and perspectives. The ancient Greek philosopher Democritus indeed proposed one of the earliest atomic theories around 400 BCE. According to his conception, everything in the universe is composed of tiny, indivisible particles called "atomos."These atomos were envisioned as being solid, unchangeable, and eternal, differing only in size, shape, and arrangement He introduced the deterministic cosmology into atomic theory, advocating that all things in the world, including the human soul, are composed of atoms. Democritus attempted to mitigate the problem by differentiating two types of movements of atoms: necessity which was purely external factors-driven on one hand and spontaneous caused by the nature of the atoms themselves on the other hand [12]. He pointed out that while the causes of human deeds are influenced by necessity, it also contains elements of spontaneity, thus allowing for free will [13]. In contrast, Aristotle, another Greek philosopher, emphasized the role of free will in moral actions, asserting that virtue arises from voluntary choices. He introduced the idea of "voluntary actions," which are decisions made freely, without external compulsion [14]. These actions are seen as expressions of free will.

In modern times, philosophers like Descartes, Kant, and Hume have offered varying images of free will. Descartes had faith in the side duality of mind and body, which was that mind possesses free will, while the physical world is governed by mechanical causality [8]. Kant considered that free will is expressed through individuals' ability to impose universal moral laws on themselves [15]. He distinguished between the phenomenal realm (the natural world, governed by causal laws) and the noumenal realm (the rational world, where free will operates). In the noumenal realm, an individual's will be free from natural causality. Conversely, Hume held a moderated deterministic view, suggesting that while people believe they possess free will, all actions are ultimately determined by prior causes [16]. Hume argued that what we perceive as free will might merely be an illusion, positing that no behavior occurs without being influenced by some cause.

In contemporary philosophy, new perspectives on free will have emerged, including compatibilism and incompatibilism, which is further divided into neural determinism and free will proponents, as shown in figure 1. The following explores these viewpoints.

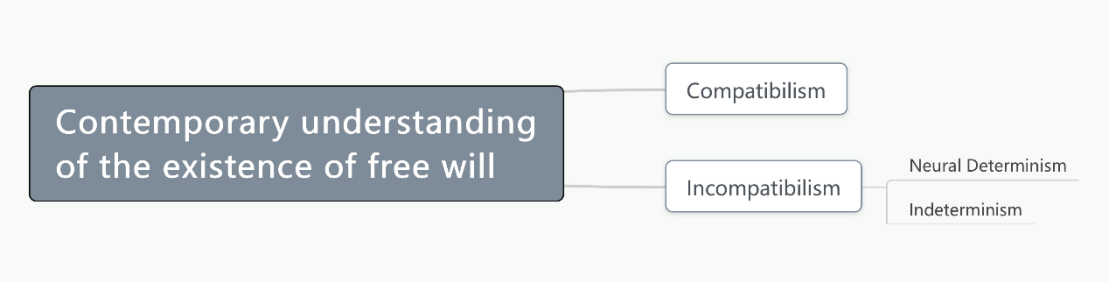

Figure 1. Classification of contemporary philosophers' understanding of the existence of free will (Photo/Picture credit : Original)

2.1. Compatibilism

Compatibilists believe that free will and determinism can coexist. Among them, the most famous libertarian compatibilist is American philosopher Daniel Dennett, who proposed the Multiple Drafts Model, which posits that the brain contains numerous parallel "drafts" that spontaneously compete and modify each other. Eventually, some of these drafts break through the boundary between the subconscious and conscious awareness, resulting in our familiar conscious experience [17]. Dennett argues that although all behavior is influenced by causal relationships, free will is still manifested in our ability to make choices based on rational reflection and evaluation. In addition to Daniel Dennett, the views of philosophers such as Harry G. Frankfurt and John Martin Fischer also provide significant support for compatibilism regarding free will.

2.2. Incompatibilism

2.2.1. Neural determinism.

Sam Harris is a leading voice in the debate on neural determinism. He believes that all our actions and decisions are driven by brain activity, genetic makeup, and the environment around us [18]. According to Harris, even if we believe in free will, it doesn't change this predetermined reality. Other modern deterministes include Daniel Wegner and Julian Baggini.

2.2.2. Indeterminism.

On the flip side, we have philosophers like Robert Kane, who argue for free will. Kane's "Reflective Choice Theory" suggests that free will isn't just about the choices we make but also about the process of self-reflection and internal debates that lead to those choices. He believes that this internal struggle is a clear sign of free will [19]. Peter van Inwagen is another philosopher who supports this idea of free will.

As science progresses, more evidence points to the physical world, including our brains and behaviors, being governed by strict cause-and-effect relationships. This strengthens the argument for determinism and challenges the idea of indeterminism. Consequently, fewer philosophers support indeterminism today. The advancements in neuroscience, in particular, have had a significant impact on modern views of free will.

3. Empirical research on free will in neuroscience

Neuroscience is the scientific study of the brain and nervous system. This field not only focuses on the structure and function of the nervous system but also explores how the brain generates behavior, emotions, and consciousness. Neuroscience explores the workings of the brain, examining the interactions between individual neurons and synapses from a micro perspective, and coordinating neural networks and brain regions from a macro perspective,

The hand-flexing behavior experiment conducted by American neuroscientist Benjamin Libet in the 1980s is often considered a milestone in the discussion of free will within neuroscience. The results of the experiment revealing that conscious decisions might not be the starting point of our

actions but rather a subsequent outcome of unconscious brain activity. The experiment overturned the traditional concept of free will and sparked much discussion. The details of Libet's experiment are as follows:

Participants were asked to perform a simple wrist-flexing movement whenever they wished. The timing of this movement was entirely at their discretion. At the same time, they need to look at a high-precision, specially designed clock. When participants wanted to bend their wrists, they were required to remember the position of the hands on the clock and report this to the researchers, and this time was referred to as the W time. The time of the participants' actual wrist movement was called M-time, and the time was measured by an instrument on their wrist. While performing these actions, the EEG device measured the participants' brain waves, assessing the most active parts of their brains by measuring the distribution of electrical currents in their brains as they bent their wrists.

The experiment found that the participants' electroencephalogram force recorded a slow accumulation of electrical activity, called the "readiness potential" (RP), which appeared before the W time. The results showed that the brain activity began before the muscle movement, a difference of about 550 milliseconds. The W time, on the other hand, began 200 milliseconds before the participants' wrist flexion. This suggests that their brains sent out the relevant signals 350 milliseconds before they "decided to bend the wrist. The entire sequence is like figure 2. “This means that unconscious brain activity occurs before we become aware of a decision, suggesting that consciousness is more of a "follower" of brain activity rather than the "originator" of actions. Thus, Libet and his team concluded, "What we call free will is actually an illusion [2]."

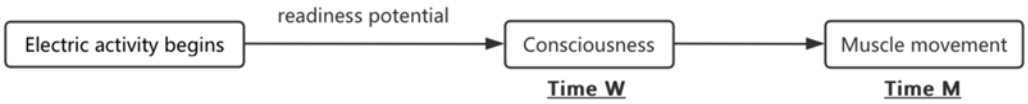

Figure 2. Libet experiment results (Photo/Picture credit : Original)

Libet's experiment sparked extensive discussion and controversy in the academic community. In 2008, South Korean scientist Chun Siong Soon and his team improved upon Benjamin Libet’s classic free will experiment. Participants were asked to spontaneously choose to press either a left-hand button or a right-hand button at any time. During this process, researchers used functional magnetic resonance imaging (fMRI) to monitor participants' brain activity, particularly in the frontopolar cortex and parietal cortex. By analyzing this data, the research team could predict which button a participant would press before they became consciously aware of their decision. Specifically, scientists were able to predict participants’ choices approximately 7 seconds before they became aware of their decision (considering the delay in blood oxygen level-dependent responses, predictive neural information might appear up to 10 seconds before conscious decisions) with an accuracy of about 60% to 70% [20]. This prediction accuracy is not very high. But considering that fMRI is a non-invasive technique and indirectly measures brain activity through blood oxygen levels might be affected by hemodynamic responses, it is understandable.

In 2011, Itzhak Fried and his team improved the prediction accuracy to 80% by using direct intracranial EEG (iEEG) recordings to predict participants’ decision intentions [21]. This series of Libet-style experiments collectively supports the idea that the brain begins corresponding activities before individuals become conscious of their decisions. This suggests that what we perceive as free will appear after the brain has already made a decision, resembling a "puppet emperor" who issues commands without real decision-making power. The "mastermind" behind the scenes would be the brain's frontopolar cortex and parietal cortex, whose brain activity indicates decision outcomes several seconds before participants become aware of their choices. Figure 3 is a conception of the relationship between decision-making and “free will” that aligns with this perspective.

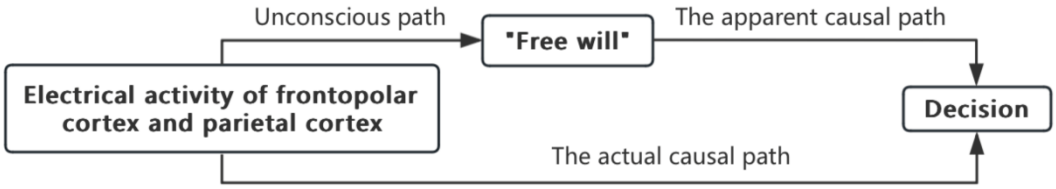

Figure 3. A conception of the relationship between decision-making and “free will” (Photo/Picture credit : Original)

4. Why do we experience a "sense of free will"?

If "free will is an illusion," what exactly makes us feel like we have free will? In other words, what are the necessary conditions for experiencing a "sense of free will"? Wegner's 2002 mouse experiment is a classic psychological study. Researchers instructed both real and confederate participants to simultaneously manipulate a mouse to move a cursor on the screen to a specific target. However, during the movement, the real participant's mouse connection was forcibly cut off, and the cursor was solely controlled by the confederate. The results of the experiment showed that participants still felt a sense of control, even though they were not actually controlling the cursor. In addition, Wegner proposed the "apparent psychological causation" hypothesis [22], in which he argued that free will is an experience rather than a cause. In fact, people strive to align their mental representations with external reality to ensure cognitive stability. Wegner also believes that the consistency between the intended behavior and its outcome forms a sense of free will. The specific explanation for the sense of free will is as follows:

4.1. Priority

The individual must have a clear motive before the action takes place. In the experiment, it is reflected that the real participant wants to move the mouse to a specific target object.

4.2. Consistency

The individual's behavior must be consistent with the preceding intention. In the experiment, both real and confederate participants moved the mouse together.

4.3. Exclusivity

The relationship between intention and behavior is exclusive, meaning there are no other apparent external reasons to explain the occurrence of the behavior. Additionally, the time gap between the intention and the behavior should be short enough to make the individual feel that their intention is indeed the cause of the behavior. For example, the experimental results indicate that the shorter the time difference between the genuine and false participants stopping their control of the mouse, the stronger the genuine participants' sense of agency.

When these three conditions are met, people are more likely to feel a sense of control over events and experience a "sense of free will." Even if this "sense of free will" may sometimes be an illusion.

5. The necessity of the sense of free will

Modern science offers counterintuitive perspectives on free will. Despite neuroscientific evidence suggesting that many decisions occur at the unconscious level, scientists and philosophers remain deeply concerned about the importance of the sense of free will. Stepping back, even if free will is an illusion, we must ask whether it is a beneficial one.

5.1. Individual level

5.1.1. Sense of value.

One significance of free will lies in its ability to impart a sense of value to individuals. When people believe they can make decisions independently, rather than being controlled by some force, they feel a greater sense of control over their lives. Observing how their actions influence the direction of their lives, this sense of agency brings a feeling of value. Moreover, free will is the premise of "freedom." Without free will, freedom itself would disappear, and a life lacking freedom cannot find meaning according to its own vision, instead following a predetermined path, which can easily lead to a sense of nihilism.

5.1.2. Creativity.

In a deterministic context, individuals would not produce genuine innovation. Determinism negates inspiration and creativity, as everything follows predetermined procedures. Free will provides a psychological sense of autonomy, encouraging individuals to explore new ideas and solutions more actively, thereby enhancing creativity and exploratory spirit in practice.

5.2. Social level

Social Order: Possessing free will means individuals are responsible for their actions. This responsibility encourages self-discipline, beneficial for maintaining social order and moral standards. In 2010, psychologist Tyler F. Stillman and colleagues published a study on how beliefs in free will affect behavior [23]. The research found that participants induced to doubt free will were more likely to cheat on tests and show less care and help for the vulnerable. This suggests that doubting free will may undermine moral and social responsibility, thus endangering social order.

Legal System: Individual free will, and the capacity to be responsible for one's actions, is the foundation of the legal reward and punishment system. Hegel, in "Elements of the Philosophy of Right," posits that free will is fundamental to human existence and the legal system [24]. Specifically, many laws derive their legitimacy from protecting individual freedom, such as freedom of speech or religious freedom. If free will did not exist, these legal systems would lose their legitimacy. Additionally, criminal law assumes individuals can freely choose their actions and thus be responsible for them. If individuals were not autonomous agents, pursuing criminal responsibility would be unreasonable.

In summary, the belief in free will has significant positive effects on both individuals and society. The belief in free will not only enhances individuals' sense of value and creativity but also maintains social order and ensures the legitimacy of the law. Even if scientific experiments cast doubt on the existence of free will, belief in it remains crucial for individual functioning, societal structure, and the underpinnings of the legal system.

6. Conclusion

Today, the existence of free will remains a complex and controversial issue. Through extensive discussion of free will, this work find that this topic is more complex than initially thought. Although modern neuroscience research, such as Libet's experiments and subsequent studies, seems to point towards a deterministic worldview, challenging traditional notions of free will, these studies do not entirely negate its existence. Instead, they offer an opportunity to re-examine the concept of free will.

This paper explored the philosophical background of free will, analyzing various perspectives from ancient Greek philosophers to modern thinkers. It evaluated the challenges posed by neuroscientific empirical research to free will, particularly studies showing brain activity preceding conscious decisions. These findings raise fundamental questions about the autonomy of individual decisions—whether our choices and actions are truly determined by prior neural activity.

However, even in the face of neuroscientific experimental results, it is believed that there are reasons for individuals to continue believing in free will. This belief not only affirms individual

dignity and responsibility but also drives social progress and innovation. The sense of free will encourages people to pursue higher moral standards and promotes the just execution of legal systems. Nonetheless, the exploration of the issue of free will should not be abandoned. With the development of new technologies, there will be more opportunities to deeply understand the workings of the brain and the nature of consciousness. For instance, utilizing artificial intelligence technologies, particularly deep learning algorithms, to simulate the complex dynamics of neural networks in the brain could help us study how consciousness and decision-making emerge within these networks. This may aid in our understanding of the relationship between decision-making and will. Furthermore, future research should increasingly adopt interdisciplinary approaches, combining philosophy, psychology, neuroscience, and legal studies to achieve a more comprehensive understanding of free will.

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