NEUROSCIENCE HAS DISPROVED FREE WILL

BSE656 – MIDTERM DEBATE REPORT – FOR THE MOTION – TEAM 1

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Introduction

One of the earliest and still ongoing debates in philosophy and psychology is the existence of free will. Generally speaking, free will is the term used to define the control a person has over their actions. (O'Connor, Christopher, 2002) The claim made by the existence of free will is that human beings can exercise freedom and the dignity of their choice remains intact. (Fieser, 2008) The contrasting view in this regard is the deterministic view. The deterministic approach claims that human choice is determined by external factors such as the environment, evolution, or even biological factors. (Mcleod, 2019)

The debate of the existence of free will took a firm root in psychology, which is the scientific study of the mind and behaviour. Development in psychology resulted in advancements in the debate. Over time, some approaches developed to psychology, each of which has been influenced by the debate. Behaviourists claim that behaviour is purely a function of our experiences within the environment, leaving little room for free will. The psychodynamic perspective, which Sigmund Freud advocated, is based on the belief that our behaviour is determined by our childhood experiences and the unconscious mind. Consequently, it implies that people have little free will to make life choices; however, this is not a very scientific theory, but it has helped shape psychology. Looking forward, we have the humanistic perspective, which believes that humans are masters of their own will and hence has been a strong advocate of the existence of free will. The cognitive perspective is one of the more recent views, which looks at mental functions like memory, perception, and attention to be closely related to the brain's physiological processes. The modern development of information processing theory has put forward the idea that the brain is simply an information processing unit that processes raw stimuli and produces an appropriate response. The biological perspective claims that all thoughts, feelings, and behaviour have a biological cause, which is further reduced to the chemistry and physics of the constituent molecules of biological systems. (Mcleod, 2013) Hence it can quite easily be seen that the debate of the existence of free will has both been shaped by and has influenced advancements in the field of psychology.

When compared to giants like psychology and philosophy, neuroscience is a relatively new field. However, neuroscience's strength lies in its rigorous scientific method. Modern neuroscientific approaches leverage the advantages of the latest advancements in technology, which continues to enable increasingly precise measurements and experiments on the hardware of our minds, our brains. This allows neuroscience to root down and provide the scientific basis for specific claims made by psychology and philosophy in the idea of free will by showing the correlation of brain activity with behaviour signalling that maybe we aren't as free as we think we are. (Gligorov, 2012)

Principal Arguments

Volition

In 1983, Benjamin Libet had conducted a hand-movement based experiment to understand the onset of neural activity for an associated motor act and the conscious experience. Participants had been asked to make spontaneous voluntary hand movements, and after each movement, they had to mention the time at which they decided to make that movement. Readiness-potential (RP) is a negative EEG component, primarily observed over the motor cortex. It reflects the onset of neural activity for carrying motor acts. In his experiment, he found that the onset of neural activity (start of the RP) preceded the conscious intention to move by at least 350 msec (Libet et al. 1983). It was concluded that motor actions are generated unconsciously and are not associated with free will. Rather, a deterministic theory may be applied to it (Roskies 2010). This experiment opened the doors for future research in neuroscience to understand if free will actually exist or not. Subsequently, several pieces of research were carried out to prove or disprove Libet's results.

Haynes et al. had conducted an experiment in which the participants had to fixate on a screen, and letters were shown to them. They could press either of the two L and R buttons and then had to report their decision timing. Neural activity was recorded using fMRI, during the task. They specifically focused on the prefrontal and the parietal cortices. Using fMRI data, they found that these regions were predictive about which button will be pressed much before the subjective awareness. This experiment showed that unconscious activity occurs in the brain for about 10 seconds before the subject's realization and encodes the person's decision (Haynes et al. 2008). Through this experiment, it can be concluded that decision-making takes place much before becoming aware of his decision. Thus, the idea of free will can be said to be an illusion.

Kerri Smith mentioned that decisions like having coffee or tea are much more complicated than the decisions in Haynes experiment about pushing buttons (Smith 2011). Real-life decisions should be involved in much more complex neural activities. Haynes et al. then conducted another experiment to strengthen their findings. In this experiment (C. S. Soon et al. 2013), participants were subjected to a constant stream of frames changing every second. Each frame consists of a letter and five numbers. When the participants felt an urge to perform the activity, they had to memorize the letter in that frame. Then they performed addition or subtraction of the numbers on the centre of the two following frames. The study concentrated on the cortical regions, which consisted of predictive information of the

abstract decision (addition or subtraction) and if there existed any information before the conscious awareness of the participant. This study found that regions of the medial prefrontal cortex and posterior cingulate encode the free choice decision before the conscious decision was made. Providing more substance to the argument that spontaneous decisions have predictive patterns before conscious awareness of the person. The pre-SMA encoded the timing of the decision. By training classifiers on the spatial and temporal patterns up to 4 seconds before the conscious decision, we could accurately predict the exact time the participants would make a decision before any behavioural response with 76% accuracy. No significant difference was found in the activity between the two choices (addition or subtraction), indicating that the decision was processed in local spatial activation patterns and not global activation magnitude. This experiment further shows a high correlation in this network of predictive regions with those found in previously conducted motor experiments.
In another experiment, subjects performed self-initiated finger movements, while neuronal activity was recorded in the supplementary motor area (SMA). It was observed that by recording the neuronal activity from just 256 SMA neurons, the subject's decision to move could be predicted with 80% accuracy. This prediction could be made about 700 msec before their awareness about making a move. This experiment concluded that the preconscious activity of a small number of neurons in the SMA preceded volition and that their activity could be used to predict volition and the time of volition. Once the neuronal firing crosses a particular threshold value, the conscious awareness about the movement occurs (Fried et al. 2011). The experiment further contributed to the idea that there is no free will and that it is just an illusion.

Counter Statements to Criticism

There are primarily three critiques of the experiments conducted by Libet and other similar predictive papers.

1. The activity measured is simply background neuronal noise (Schurger et al. 2016).
2. The activity measured results from the motor preparation for the task (Lara Boyd et al. 2009).
3. The unconscious neural activity reflects the decision process itself rather than the result of an unconscious decision (M. Brass et al. 2019).

On examining the relation of the predictive brain signals with the activity in task negative DMN (Default Mode Network), it is noticed that there is a high activity during the period before the decision. This shows that there is no conscious engagement with the task and upcoming decisions, and participants are not busy thinking of the tasks.
The abstract intentions experiment (Soon et al. 2013) is nonmotor (abstract decision). Nor was there any motor activity decision encoded in the examined regions (during the entirety of the experiment), thus we can conclusively say that the frontoparietal network is involved in the formation of free intentions and not in motor preparation.
Schruger argues that the activity until 200ms is just neuronal background noise and not the upcoming voluntary task's unconscious decision. But this assumption fails to answer the high degree of predictive accuracy of these experiments. And the consistent spike in the activity posterior cingulate and medial frontopolar regions before every conscious decision is taken.
An experiment conducted with the same setup as that of Libet's, but on subjects with parietal lesions (Desmurget et al., 2009), showed that awareness came only when the actual action was carried out. This impairment had thus, eliminated the period of consciousness immediately before the actual action was carried out. A theory was proposed to explain this delay, which said that the parietal cortex generates an inherent predictive model of the movement to be carried out at the time when this movement is being planned, and awareness pertaining to this movement might be determined by the neural basis of this model, further neglecting the aspect of free will. This provides further justification that the activity could not merely be a part of the decision process, but rather the entire decision is taken without any voluntary, conscious action.

Unreliability of Conscious Intention

The theory of unreliability of conscious intention seeks to empirically prove the role of consequences and the events happening after the action was performed (after awareness was gained) on the conscious intention and the action decision's subjective perception. Branching from the theories mentioned above, this strives to show how subjective consciousness can be manipulated using experimental settings and results. Therefore, it does not play a role in decision making, further strengthening the notion against free will.

In an experiment (Banks & Isham, 2009), where participants had to push a button whenever they wanted and later report the exact time when they had an intention to push the button, auditory feedback was given as the button was pressed with a time delay of 5-60ms. The thought behind a slightly delayed feedback was to let the participants believe that the response happened after pushing the button as the participants did not know about this delay. As a result, the participants reported the intention to press the button later in time than the actual moment. The conclusion drawn was that people tend to report the intention to decide based on the consequences and not just the actual motor action.

Another experiment (Kühn & Brass, 2009) that sought to empirically prove this theory was when the participants had to react as soon as possible to a stimulus shown by pressing a button. Just after the stimulus was displayed, a stop signal (try not to respond) or a decision signal (could choose whether to respond or not) appeared sometimes. The participants were then asked after the trials in which they had responded, whether it was because a decision was made or were, they are simply unable to stop. The results concluded that some of the trials in which the participants had responded and thought they had made a decision were a failed inhibitory action, or in other words, had a subjective understanding of having taken a decision. This strengthens the theory that consequences have a strong influence on conscious intention. This also takes into account internal and external contextual information, which will be discussed later, and goes on to say that once there is an awareness that a movement has occurred is going to occur, subjective perception of a conscious intention is decided.

Bayesian Brains

Computational theories of brain function have become quite influential in neuroscience. In this regard, a central idea is of Bayesian Brains, which claims that our brains are nothing but probabilistic prediction engines. (Clark, 2013) The idea is that the brain creates an internalized model of the world. This model is developed by gaining information from the surroundings through interactions and feedback mechanisms. This internal model is then used by the agent to explain its sensations as accurately as possible, with the least amount of information. Another aspect of this modelling is when the brain uses an internal model to predict the most optimal action. The global thermodynamic entropy functions define the most optimal action. Overall, many brain function theories can be reduced to a Bayesian model, where the brain is an interference engine. This model has proved successful in modelling, motor control, predictive coding, inference models, theories of attention, optimal control, and many more exciting phenomena. (Friston, 2010)

What does this have to do with the percept of free will? The Bayes model is essentially backed by the fact that the agent is completely expected to work with the information that they gain from the environment. The environment plays a critical role in shaping the internal model on which the agent's actions are based. Combined with uncertainty arising from the role of random events in decision making, the success of the Bayesian brain gives us a strong indication of the lack of free will.

Behavioural Variability and Reflex Actions

For free will to not exist, actions must be determined beforehand somehow (Koch C. 2009). But this does not mean that there is determinism. In fact, it has been argued against and proved to be of no existence (Cashmore A. R. 2010). One might now conclude that indeterminism defines actions, leading them to freedom. But all this is not so simple.

Determinism in a biological framework would mean that the traits and behaviour of species will be predictable (Koch C. 2009), eventually leading to predictions in extinctions and survival of species, which is clearly not the case (Björn Brembs 2010). In fact, responses of 2 individuals in the same conditions or the response of the same organisms in the same conditions at different times usually vary, bringing in a factor called behavioural variability. Behavioural variability probes to be of crucial importance in improving the chances of survival (Domenici P., Booth D., Blagburn J. M., Bacon J. P. 2008) (Fishes with C-start response getting hunted by snakes: Korn H., Faber D. 2005; Catania K. C. 2009; Catania K. C. 2010).

Our responses are influenced by exogenous and endogenous factors and under the command of our brains (Roberts S., Gharib A. 2006). Behavioural variability as a response depends on endogenous factors. The corresponding variability can be controlled or modified on the exposure of external stimuli withstand a change to optimize survival-predictability responses (Overcoming depression and autism is a good example). Discoveries have found default networks in humans whose dysfunction causes disorders.

Till now, unpredictability might have created illusionary freedom, which is exactly not the case. Brain functions (In Rodents, Barrel Cortex was found to show this function) in such a way that it amplifies slight differences in otherwise broadly similar environments, enforcing behavioural variability.

Reflex actions come out as a special case of this, where they have been observed to be modified in some organisms. In common experiments promoted as a display of reflex actions (like the leg jerk when you are hit below the knee experiment), even though the outcome is known and might even be resisted, sometimes we often end up with similar responses, usually with varied intensity. These certainly do not stand with traditional ideas of free will.

Predicting Choices, Evidence Accumulation and Role of Contextual Information

A multivariate pattern classification analysis (MVPA) methodology of incorporating neural patterns and machine learning algorithmic classifiers, which collated fine-grain patterns from fMRI studies on Libet derived and extended experiments (subjective and objective), had a significant impact on the path towards predicting choices as stated above (Soon et al., 2008). As attempts were made to build over these notions, it has been known that decision making is not a seemingly simple task but requires heavy and complex machinery of cognitive processing mechanisms which employs both conscious and unconscious neural activity in a variety of contextual information. Further insight into the debate was made by looking for models that describe the decision-making process while taking into account context and its corresponding evidence (Bode et al., 2012).

Evidence-accumulation models for cognitive decision-making are employed, which attempt to predict choice outcomes of perceptual decisions using a decision variable which varies with the evidence presented and culminates into a decision threshold to reach a decision. An important aspect of this application is the role of external and internal factors (causal factors). Even in the absence of external factors (free decisions/guesses), the models and classifiers give similar predictions (Bode et al., 2013), especially for near-threshold decision variables. This shows that internal context plays a major role motivated by stochastic noise and preceding decisions (bias) with or without external feedback (the previous decision may act as external feedback (Akaishi et al., 2014) but without conscious awareness (at a micro decision level) at the moment. A significant impact on the medial posterior parietal cortex/posterior and posterior cingulate cortex was observed pertaining to decision history (Bode et al., 2011). These decisions compiled together shape brain activity and decision making with a convergence of external and internal contexts. The gradual build-up of evidence and corresponding decision variables, which can be predicted and simulated while often being unconscious, further strengthens the notion of free will as an illusion.

There have been several experiments that use evidence, accumulation models to study fine-decision making in neural context (or drift-diffusion models to simulate the results computationally). Here, we describe experiments pertaining to non-human primates performing a simple direction discrimination task in which a collection of dots move randomly either to the left or the right, and the primates (monkeys in this case) make a saccadic movement to look at the left or right response corresponding to movement.

The first experiment (Shadlen & Newsome, 2001) showed that as the stimulus is presented over a period of time (time for evidence accumulation), the information in the sensory regions of middle temporal (MT) and upper-middle temporal (MST) areas and so increases the activity of the neurons in the Lateral InterParietal region (LIP). The strength of the accumulated evidence (discharge rates) once rises up to a certain threshold; the monkey makes a saccadic movement to mark its response. The decision variable and accumulated evidence also vary as the time of stimulus presentation changes, if the monkey decides to not respond to the trial and on a few other parameters. Interestingly, the neurons keep discharging even in the absence of visual stimulus in a case where the monkeys are asked to wait until a signal tells them to respond (Gold & Shadlen, 2007).

Building on the above-mentioned experiment, a study attempted to observe the effects of cortical microstimulation on confidence and decision making (Fetsch et al., 2014). This paper attempts to elucidate the relationship between confidence, accuracy, and response time and, in the process, employs an evidence accumulation model and shows the neural basis of decision making and the effect of external manipulation (induced external context). In the same setting, a third response is added to trials in the form of a lower but guaranteed reward, majorly to study confidence. Electrodes implanted in Cortical and Interparietal regions of the brain pass low values of current in direction-selective neurons (which are biased towards one direction) so as to manipulate the decision-making process. Extremely accurate results were drawn portraying the relationship of the parameters of decision making (confidence, accuracy, and reaction time) and cortical microstimulation led to the primary conclusion that this small current passed does not interfere with visual signals, but rather the evidence accumulated on the basis of the stimulus. Activation of direction-selective neurons developed a bias as apparent through the model. The conclusions drawn thereby necessitates a neural basis to decision making as a whole. Even though the monkey was conscious and seeing a similar stimulus, a change in physical neural basis led to a change in evidence which ultimately, led to a change of decision and associated confidence (The same was simulated in the form of a drift-diffusion model too).

Conclusions

A lot of empirical experiments have been conducted alongside theories on cognitive, spontaneous, free decision making as well as guesses, and it has been widely concluded that there remains a physical neural basis to this aspect and awareness and consciousness is either absent altogether, present but delayed, subjectively varied, and/or manipulated with internal and external contextual information. The evidence and arguments towards disproving free will and elucidating the role of a physical neuronal basis along with current research opportunities in this topic and future prospects of unlocking the potential of cognitive and perceptual aspects of decision-making imply the complexity of processing. This also goes on to say that the metaphysical concepts of subjectiveness, consciousness, and free will, which are believed to be present, might virtually be products of this complex processing and as we attempt to disprove them going into the future, it is of paramount importance to quantify and model this processing to achieve a proper explanation and insight.

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