

Libet's experiment provides no evidence against strong libertarian free will because readiness potentials do not cause our actions

Daniel von Wachter*

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Abstract

This article argues against Benjamin Libet's claim that his experiment has shown that our actions are caused by brain events which begin before we decide and before we even think about the action. It clarifies what exactly should be meant by the RP causing, initiating, or preparing an action. It argues that Libet's claim is incompatible with strong libertarian free will. It shows why Libet's experiment does not support his claim and why the experiments by Herrmann et al. and by Trevena & Miller provide evidence against his claim. The empirical evidence is compatible

*International Academy of Philosophy at the Pontificia Universidad Católica de Chile, <http://von-wachter.de>, email: epostATvon-wachter.de. This research was carried out in project [Fondecyt 1100608](#) funded by the Chilean institution Conicyt.

with strong libertarian free will. Neither the readiness potential (RP, Bereitschaftspotential) nor the lateralized readiness potential (LRP) causes our actions.

Keywords: libertarian free will, Libet, neuroscience, Bereitschaftspotential, readiness potential, mechanismism

1 Introduction

Although Benjamin Libet's interpretation of his experiment concerning free will has received much criticism¹, many people still believe that he has provided evidence for the claim *that all our actions have unconscious causes that begin before we even think about the action*. To this claim I refer as 'Libet's claim'. In this article I want to show that the experiment does not even provide evidence for the thesis that the actions investigated, let alone *all* our actions, have preceding unconscious causes. The 'readiness potential' (RP) or 'Bereitschaftspotential', which Libet claimed to cause the action, is not a cause of the action but only what the name which its discoverers, Hans Helmut Kornhuber and Lüder Deecke (1965; cf. Jahanshahi and Hallet 2003 and Shibasaki and Hallett 2006), gave to it, and which is also used as a German lone word in anglophone neuroscience, suggests: a readiness potential ('Bereitschaftspotential'). I shall proceed by addressing the following points:

- Summarize Libet's interpretation of his argument.
- What does it mean that a certain event 'caused' the action?

¹Libet described the experiment in Libet et al. 1982 and Libet et al. 1983 and interpreted it further in Libet 1985 and Libet 1999. For criticism see the 'Open Peer Commentary' in Libet 1985, pp. 539–566, the journal *Consciousness and Cognition* [volume 11, 2011, number 2](#), Sinnott-Armstrong and Nadel 2011, Swinburne 2011, Deecke and Kornhuber 2003, Batthyany 2009. In what follows, publication years refer to Libet's articles unless specified otherwise.

- Why does Libet’s claim contradict belief in free will?
- Libet’s defence of the claim that the RP causes the hand movement
- New experiments showing that the RP does not cause the hand movement

2 The popular interpretation of Libet’s experiment

(2.1) The popular picture, which Libet spread himself in his articles about free will (for example in 1999), goes like this.

In his experiment Libet told some test persons to move their hand when they wanted to, voluntarily, spontaneously, ‘on her/his own initiative’. (1999, p. 47) He wanted to know: ‘*when* does the *conscious* wish or intention (to perform the act) appear?’ (1999, p. 49) Therefore he gave the test persons a special clock and asked them to report the time ‘at which he/she was *first aware* of the wish or urge to act’. This first awareness is referred to as ‘W’. Libet measured when the muscle activity and when a certain brain activity, the ‘readiness potential’, RP, began. The result was that W begins 200 ms (milliseconds) before muscle activity, and RP begins 350 ms before W. Therefore ‘the volitional process is [...] *initiated* unconsciously’, before the agent even thought about it. (1999, p. 47)

(2.2) I have shown elsewhere that this description of the experiment is wrong and that Libet used the words ‘voluntary’ and ‘spontaneous’ misleadingly. In fact the test persons were not told to move their hand ‘whenever they want to’, but, to the contrary, they were told to move their hand only when an urge

to do so arises. The hand movements investigated were more like involuntary fits than like voluntary actions. If we have free will, then these hand movements may well have unconscious preceding causes, while actions of the kind that Libet did not investigate do not have such causes. However, in the present article I put this issue aside and investigate only whether Libet has provided evidence for the claim that the RP causes the hand movement.

3 What does it mean that the RP ‘caused’ the action?

(3.1) Libet claimed that the RP *caused* and *initiated* the actions investigated and indeed all actions. Let us clarify what ‘causes’ here means. If somebody’s lighting a pipe caused an explosion in a room with gas, then in some very general sense it is also true that the presence of the gas before the occurrence of the spark caused the explosion. But that is not the sense we need for ‘The RP caused the action’, because in this sense it would even be true that the hand’s existence five seconds before the movement caused the movement.

(3.2) What is meant is that the RP, *from its onset*, is a part of a *complete*, non-probabilistic cause of the movement, and that the other parts alone could not have caused it. In the Hobbesian tradition one would say that the RP is a part of a ‘sufficient’ cause, in the sense of a ‘necessitating’ cause. As in my view (Wachter 2012) it is impossible that an event necessitates a later one, I should look for a weaker interpretation: The process that led to the movement was already under way at the time of the RP, and the RP was a part of that process. For expressing this we need, instead of the idea of necessitation, the idea of a process heading towards a certain event. I say in this case that the state of affairs (or ‘event’) which is a stage of the process is the basis of

a ‘tendency’ towards that later event, where ‘tendency’ does not have the implication of being probabilistic. (Wachter 2009, ch. 5) With this terminology Libet’s claim that the RP caused the action means that the RP, from its onset, was a part of a state of affairs that was the basis of a tendency towards the movement. The state of affairs did not necessitate the movement – although the process was not probabilistic – because it was possible that something would stop the process, as Libet recognized when he affirmed the possibility of ‘vetoing’. (Libet 1985, § 4.1) The only possibility how it might not have led to the movement was that something stops it. It could not stop by itself, by chance.

(3.3) Libet claimed that the actions he investigated and indeed all our actions are *initiated* by a RP.² We best understand this as an addition to the claim that the RP causes the action. It entails the claim that the RP is a part of a complete cause of the movement, and adds to it the claim that *before the RP there was no process heading towards the movement*. With my terminology, before the RP there was no state of a affairs that was the basis of a tendency towards the movement. Without the initiating event, things would have developed differently, the hand would not have moved (if also nothing else caused a movement). The things or states of affairs with which the RP cooperates to move the hand

²Libet’s claim that the RP ‘initiates’ the action is contained even in the subtitle of his 1983 paper, ‘The unconscious initiation of a freely voluntary act’, and in the title of his 1985 paper, ‘Unconscious cerebral initiative and the role of conscious will in voluntary action’. In 2003 he repeated this, saying that his experiment ‘produced evidence that the brain appears to initiate a freely voluntary act well before the subject is aware that he wishes or feels the urge to act’. (p. 325) Still in Libet 2006 he claimed that ‘free will could not initiate the volitional process’ (543) and that he had found out ‘that a voluntary act is initiated unconsciously’ (546).

are activated through the initiating event.³

(3.4) The claim that the RP caused the movements is relevant for free will because the RP is *unconscious*. That means that the person is not aware of the RP and that it is not linked with a mental, conscious event. The RP begins before W and thus before the any mental event that may be a cause of the action. Therefore I express Libet's claim that the action was caused or initiated unconsciously also by saying that it was caused or initiated before the person even thought about it.

(3.5) Finally, we need to need to spell out the alternative to Libet's claim that the RP caused the movement: that the RP was, or was associated with, a preparation of a possible action, or an expectation, or a state of readiness to act in one way or another. This means: At the time of the onset of RP there was no complete cause of the movement, there was no process towards the movement under way. But later, when some further event occurs, it (as well as some other states) became a part of a complete cause of the movement.

4 Libet's claim is incompatible with free will

(4.1) Libet's claim that the hand movements which he investigated were caused by the RP is compatible with free will, because other actions, which differ from the actions he investigated, might not have preceding unconscious causes. But as he alleges, and as I accept only for the sake of the argument in this article, that the actions he investigated were 'voluntary' and that thus if any actions have no preceding unconscious causes, then these do, he

³If you do not want to hold that before the RP there was no process towards the movement, because you believe that for any event there is at any time before a process heading towards it, then you can make sense of 'initiate' by taking it to mean just that it activated certain things or states of affairs to bring about the movement.

derives from this his general claim that *all* our actions are initiated unconsciously. Libet presented this claim as being incompatible with or limiting free will. I believe that this is correct, but many philosophers replied that it is compatible with free will.

(4.2) Compatibilists believe that an action's being free is compatible with its being the result of a causal process and that the reasons for an action (or the beliefs in them) is amongst its causes. Therefore at least for some compatibilists, free will is compatible with Libet's experiment. Only some stronger, libertarian notions of free will might be in conflict with Libet's claim. Thus some philosophers defend free will against the evidence from neuroscience by saying: 'Only a very old-fashioned, mysterious kind of free will is incompatible with Libet's experiment. Nobody would defend that nowadays.' Alfred Mele for example, although he calls his view libertarian, writes:

Only a certain kind of mind-body dualist would hold that conscious intentions do *not* 'arise as a result of brain activity'. And such dualist views are rarely advocated in contemporary philosophical publications on free will. (Mele 2006, p. 40)

(4.3) There are views which are sometimes called 'libertarian' but which nevertheless are compatible with Libet's claims and therefore are called 'modest' (Mele 2006, p. 10; Mele 1995, pp. 211–221; Clarke 2000), 'credible' (Clarke 1993), or 'non-mysterious': First, some hold that, *additionally* to having event causes (deterministic or indeterministic), actions are caused by agents by so-called 'agent causation'. (Chisholm 1976, p. 201, Clarke 1993, Swinburne 1997, p. 231) Second, some hold that actions have event causes but the process of deliberation must be indeterministic (Mele 1995). Third, some hold that the action itself must be caused indeterministically (Balaguer 2009). Such views are compatible with Libet's claim because their defenders could say

that the action is caused by the agent as well as by the RP, or they could say that the RP is just an indeterministic cause of the action because all brain processes are indeterministic.

(4.4) But there is a stronger view of free will, which is more clearly in conflict with Libet's claim. The claim that conscious intentions do not 'arise as a result of brain activity' is not, as Mele says, *dualism*. A dualist could hold this claim, saying that there are causal processes going from the soul to the brain. But only some dualists will hold this, and it is in my view not a solution of the problem of free will. Rather, the claim that conscious intentions do not 'arise as a result of brain activity' is the denial of *mechanicism*, which is the view that *every event, necessarily, is the result of a causal process*. Although for many centuries many philosophers did not believe in mechanicism, today many have so internalized the doctrines of Hobbes, Descartes, and Kant that they cannot imagine that one can reject mechanicism.

(4.5) In order to illustrate that one need not believe in mechanicism and to show that Libet's claim, as he rightly suggests, is in conflict with free will, let me sketch my strong libertarian theory. (Wachter 2003; Wachter 2009, ch. 7) In free actions the action process (i. e. the process that leads to the intended result, e. g. the movement) has a beginning at least a part of which has no preceding cause, neither a deterministic nor an indeterministic one, but its occurrence is due to the agent. It is *an event that has no preceding cause but is brought about directly by the agent*. I call such an event a *choice event*. Agents have the power to make certain events pop up. Through this they can initiate causal processes. (Therefore my view can be called the 'pop up view' or the 'initiation view'.) So there is a third way how an event can come about, besides being the result of a deterministic process and being the result of an indeterministic process. Choice events are brought about by the agent in the light of reasons or following inclinations, but reasons (or belief in reasons) and inclinations

are not event causes of the actions.

(4.6) Whether we call the agent the ‘cause’ of the choice event, as the defenders of agent causation would say, or say that the choice event was ‘uncaused’, as the defenders of noncausal theories say (Ginet 2007), does not matter here. That is just a matter of how the word ‘cause’ is ordinarily used and in how wide a sense we want to use it. What matters for our discussion of the neuroscientific data is that a choice event has no preceding event and that the agent initiates a causal process. Therefore, if Libet’s claim that ‘the volitional process is [...] *initiated* unconsciously’ (1999, p. 47) were true for all our actions, then there would be no strong libertarian free will.⁴

5 Libet’s defence of the claim that the RP causes the movement

(5.1) In order to defend my claim that the RP does not cause the hand movement – not even in the cases which Libet investigated, let alone in all actions – I shall now describe some flaws in Libet’s argument.⁵ Libet first conducted trials with three persons, ‘group 1’, and ‘after a few months’ (1982, p. 323), with three different persons, ‘group 2’.⁶ With each test person Libet conducted series of 40 trials each. Of each series he formed the *averaged* values of RP detection. (1982, p. 324) The test persons were watching a kind of clock with a ‘cathode ray oscilloscope’ (CRO) spot

⁴Other authors who claim that actions involve events that have no preceding cause are Ginet (2007), Lowe (2008, p. 12), and Meixner (2004, ch. 9).

⁵That the RP does not cause the movement has been argued by: Trevena and Miller 2002, pp. 185, 187; Roskies 2011, 16 l (left column); Mele 2011, p. 25 l; Pockett and Purdy 2011, p. 34 l.

⁶In the table with the measurement data (1983, p. 630) Libet omits one person from group 1, M.B. The reason which he indicates is that ‘the quality of the EEGs and the minimal amplitude of the RPs of one precluded using much of her data.’ (1983, p. 624; 1982, p. 323)

moving round. In the first trials each test person were instructed ‘to wait for one complete revolution of the CRO spot and then, at any time thereafter when he felt like doing so, to perform the quick, abrupt flexion of the fingers and/or the wrist of his right hand’. The persons were asked to report the time, *W*, of their first awareness of the urge.

(5.2) These instructions did not mention *urges*. But after some trials, for ‘the latter half to two-thirds of sessions with group 1’ (1982, p. 324; 1983, p. 625), a further instruction was added: ‘let the urge to act [move their hand] appear on its own at any time without any preplanning or concentration on when to act’. (1982, p. 324) (Why did Libet not say exactly, when this further instruction was introduced?) Libet does not tell us why this instruction was added, but perhaps the reason was that the results varied strongly, or perhaps there was no RP before *W*. ‘After a small number’ (1982, p. 325) of series in group 1, that is towards the end of the experiment with group 1, the test persons were asked after each series ‘whether they were aware of any pre-planning’. (1982, p. 325) (Why did Libet not say exactly, when this question was introduced?) Apparently, in the trials in which the test persons reported no preplanning the RP started later.

(5.3) The results still varied strongly: ‘Under our conditions RPs varied considerably in form and duration, even for a given subject in the same session.’ (1982, p. 326). Libet distinguished three types of averaged RPs, depending on their form and ‘the time at which the main rise in negativity begins’. (1982, p. 326) ‘Type I RPs’ he called those averaged RPs which began more than 700 msec before the hand movement. (‘In the more extreme examples of type I [...], which appeared [...] before introducing the instruction for “spontaneity”, the RP appeared to have begun rising well before the -1400 msec of the available pre-event recording time.’) ‘Type II RPs’ he called those averaged RPs

which began 400 to 700 msec before the hand movement. ‘Type III RPs’ he called those averaged RPs which began 200 to 350 msec before the hand movement.

(5.4) Libet presented as the result of his experiment that the RP begins 550 ms before the movement while the first awareness occurs at 350 ms before the movement. (1985, p. 529; 1999, p. 47) For calculating these 550 ms he used only the results from experiments with type II RPs. This raises questions. If one obtains very different results when one conducts an experiment several times, then it is of course wrong to distinguish three kinds of results in order to use only one of these kinds for justifying one’s conclusion. Is there a justification for omitting the type I and the type III results? The only candidate for a justification is the claim that *only* in the trials with type II RPs, and in *all* these trials, there was no preplanning.

(5.5) Although the justification of Libet’s omitting the type I and the type III results depends on this, the information about in which trials the persons reported preplanning is difficult to find in Libet’s articles and not entirely consistent. Let me quote everything that Libet says about this:

1. The mode of questioning subjects about the state of pre-planning [...] could only provide limited indications about the relation of these states to types of RPs, chiefly because it was impractical to question the subject after each individual trial. (1982, p. 327) [Why is that so? If the definition of ‘preplanning’ is sufficiently clear at all, it should be easier for the test persons to say after each trial whether there was preplanning than to say after 40 trials whether there was preplanning.]
2. ‘Pre-planning’ or ‘pre-intention’ in some form was reported by the 3 subjects in group 2 and subjects S.S. and C.M. in group 1 in a total of 9 series. In 8 of these 9 series the RP was a type I (the exception was a type II, in subject B.D.). The subjective contents of these recalled awarenesses contained some important

features. Subjects reported being aware of some ‘preplanning’ in only a minority of the 40 self-initiated acts that occurred in the series for that averaged RP. The subjective recollection was most often one of having a general intention or anticipation of performing the act during a forthcoming period of time, when the moving CRO spot would have entered a specific portion of its revolving circle. (1982, p. 328)

3. For the 14 series with such reports [of *no* pre-planning for *any* of the 40 acts in the series], essentially none of the RPs were type I (one of these RPs was regarded as borderline I-II), while 9 were type II and 4 type III. (1982, p. 329)
4. Self-initiated acts arising ‘spontaneously’, with no experience of preparatory pre-planning or pre-intention to act, were associated with type II RPs. (1982, p. 333)
5. Type II (and III) RPs are obtained when all 40 self-initiated movements in the averaged series are reported by the subject to have originated ‘spontaneously’ and ‘capriciously’, with no recollections of preplanning experiences for any of the 40 events in the series. Additional experiences of a ‘preplanning’ phase are associated with type I RPs. (1983, p. 632)
6. All subjects reported that they could distinguish readily between this awareness [W] and any experience of ‘preplanning’ that sometimes occurred in acts associated with type I RPs [...]. Awareness of ‘preplanning’ were completely absent in series associated with type II (or III) RPs. (1983, p. 635)
7. Actual experiences of ‘preplanning’ were reported for only a minority of self-initiated acts in series with type I RPs. [...] In series with type III RPs, all self-initiated acts were also spontaneous [by this Libet means without preplanning], as in type II. (1983, p. 636)
8. A ‘preawareness’ that one is preparing to perform the voluntary act, sometime within the next second or so, does in fact accompany at least some of the events in those series that produce a

type I RP, as noted above. [...] In series giving type II RPs, all of the self-initiated acts were described as ‘spontaneous’; the subjects reported that each urge or wish to act appeared suddenly ‘out of nowhere’, with no specific preplanning or preawareness that it was about to happen. (1983, p. 638)

(5.6) In none of Libet’s articles we find precise information about how ‘preplanning’ was explained to the test persons, how the questioning was conducted, and what the exact answers of the test persons after which series were. The most precise information is quotation 2 from 1982. Many researchers about free will do not study this article, because they have no access to it or because its thesis is not directly relevant for free will. The articles that are studied more often (1983 and 1999), do not contain this information. In 8 of all 9 series with preplanning, the RP was of type I. Was in all series without preplanning the RP of type II or III? Yes, nearly. According to quotation 3 (and in accordance with quotation 7), of 14 series without preplanning, 9 had RPs of type II, 4 had RPs of type III. (Libet considers here only the trials with group 2, presumably because the majority of trials with group 1 were without the instruction to avoid preplanning and without the question about preplanning.) But why then does quotation 4 say that preplanning is associated with type II RPs? ‘Associated’ here must mean that type II RPs occur always and only in series without any preplanning. That would have to be true if Libet’s leaving aside the type III RPs were to be justified. But it follows from quotations 2, 3, 5, 6, and 7 that it is not true: in series without preplanning there are not only RPs of type II, but also RPs of type III.

(5.7) Let us then look at the variation of the time of RP onset in group 2 in all series without any preplanning, that is, (if we trust Libet’s statements about where preplanning was reported) in all series with RPs of type II or III. Here are the RP onset times for the various test persons:

- for S.B. between -900 and -550 msec;
- for G.L. between -800 msec and -500 msec;
- for B.D. between -650 and -225 msec.

The corresponding variation of the time difference between RP onset and W:

- for S.B. between 439 and 755 msec;
- for G.L. between 500 and 800 msec;
- for B.D. between 80 and 504 msec.

So in some series the RP onset was measured just around one tenth of a second before the report of the first awareness of the urge. Given the difficulties in measuring W, the results leave open the possibility that in some cases the RP started after W. The reason for this need not be that the RP sometimes begins after W, it could also be that the RP behaves very different in different people or different cases, or that the experiment is imprecise.

(5.8) Perhaps we should even leave aside the difference between trials with preplanning and trials without preplanning. Because it is unclear what a preplanning before an urge should be, and surely it is difficult to obtain exact information about the occurrence of preplanning. Given that all test persons were instructed to move their hand, all of them must have thought about the movement in some way, and the boundary between trials with preplanning and trials without is surely vague, and the different persons may have treated it differently.⁷ If we leave aside the distinction

⁷Talmy and Frith 2011 note that the instructions are manipulative: ‘First, the instructions convey a strong implicit message that the participant *should* have an urge to move their finger during the course of the experiment, and that they should have more than one such urge. Second, the instructions

between trials with preplanning and trials without, the RP onset is between -1400 msec and -225 msec, and the time difference between RP onset and W is between 80 msec and 1129 msec.

(5.9) There is another reason why we should leave aside the distinction between trials with preplanning and trials without: If, as Libet claims, the RP initiated the action process in the cases without preplanning, then it would surely do so also in the cases with preplanning. Furthermore, Libet's claim is that *all* actions are initiated by RPs. That commits him to holding that also the movements with preplanning are initiated by RPs. And if Libet wants to leave aside the cases with preplanning, then he has to assume that in those cases the RP does not initiate the action, but, presumably (given that he does not want to accept that the mind initiates the movement some time after RP), the preplanning initiates the action. That would mean that, contrary to Libet's claim, a *conscious* event initiates the action.

(5.10) But even if we leave aside the series with type I RPs, given that the series without any preplanning constitute a very homogeneous set of trials, the variation is much bigger than we should expect on the assumption that the RP causes the movement. Because if the RP were the initiation of the action process, then the time between the RP and the beginning of the muscular activity should be always roughly the same, because causal processes of the same type have the same velocity. As sound travels always with the same speed through air, and the time between a pin being pricked into your left toe and the beginning of the pain is always the same, so should the causal process from the initiation of the action process to the hand movement always take the same time. Note that the numbers

convey the message that there is a particular temporal pattern of finger movement that is "correct". The participants were instructed to "let the urge happen on its own at any time" implying that movements at some particular time would not be right.' (p. 128)

which are given for the time of the RP onset are each already the average of 40 movements. The real variation of the results may therefore be even much bigger.

(5.11) What does the fact that in cases with preplanning the RP starts earlier show? It arbitrates between the hypothesis that the RP initiates the action, and the hypothesis that the RP does not cause the action but is only a preparation for a possible movement? On the assumption that the preplanning does not cause the action and the RP does cause it, we should expect that the time between the RP and the movement is the same as in cases without preplanning. The preplanning might make the urge and the movement occur earlier than they would occur without the preplanning, but the preplanning would not lengthen the time between RP (the initiation of the movement) and the movement. But the assumption that the RP does *not* cause the movement but is a general readiness to act, explains why in cases with preplanning the RP begins earlier.

(5.12) I conclude that Libet's claim that the RP initiates the hand movement is false and that the RP is a state of preparation for a possible movement. The presence of the RP may shorten the time between the initiation of the movement and the movement. But the RP, at least at the beginning, does not initiate the process leading to the movement and it is not a part of that process, because there is not yet such a process. It is like the presence of the gas in a room before the explosion caused by someone lighting his pipe: It exists already before the explosion is initiated by the spark. Before the spark occurs, there is no process, and the presence of the gas is neither a complete cause of the explosion nor a part of it.

6 Herrmann's experiment shows that the RP does not cause the movement

(6.1) One can improve our knowledge about the connections between free actions, conscious events, and brain events by conducting experiments which

1. let test persons act whenever they want to, rather than, as in Libet's experiment, just on an urge;
2. compare actions and omissions;
3. give a choice between different actions;
4. test not only choices of equal value but also cases where one choice is believed to be better than the other, with or without a counteracting temptation.

(6.2) Christoph Herrmann et al. (2005) conducted an experiment with a choice between different actions. If the RP begins before the choice is made, then the RP does not cause the action. The test persons are instructed to press a certain button with their left hand when they see a certain symbol on a screen, and to press a button with their right hand when they see a certain different symbol. This avoids all the imprecision and uncertainties that are involved in the measurement of Libet's event W. The result is this:

'Our results show that the neuronal activity that occurs before the motor reactions begins already at a time when the test persons can not know yet whether they shall press the button with the left or with the right hand. Therefore the observed activity cannot be considered to be a specific preparation to press one of the two buttons.' (Herrmann et al. 2005, 128; my transl.)

The authors therefore reject Libet's claim that 'the brain "decides" to initiate or, at least, to prepare to initiate the act before there is any reportable subjective awareness that such a decision has taken place' (Libet 1985, p. 536 l):

'Because the RP begins before the signal and the test persons react correctly, the RP cannot determine which of the two available alternatives (movement of the right or the left hand) will be executed. Instead the RP seems to represent a general expectation.' (Herrmann et al. 2005, p. 130)

(6.3) This is correct. As we have seen above (§ 3), Libet's claim that the RP caused the action, means that the RP was a part of a complete cause of the movement. If this were true, then already at the time of the signal, a process would be under way towards one of the two possible actions. We should therefore expect that only 50 percent of the movements correspond to the signal. But in fact the test persons react always correctly to the signal.

(6.4) It is too complicated to assume that always when the signal occurs, there is already a process under way, and where necessary the persons veto this process. There is no evidence for the assumption that there are two kinds of cases, one with vetoing, the other one where the process by chance is already directed towards the correct movement. The test persons feel no pressure or inclination to move one hand rather than the other. The only motivation they have to move one hand rather than the other is the signal. It is therefore much more probable that the process towards one or the other movement begins after the signal, when the test person has seen the signal and makes his corresponding decision.

(6.5) I conclude that Herrmann et al. (2005) have provided evidence for the the thesis that the readiness potential does not cause the action but is only a state of preparation or expectation

(as defined in § 3.5). It is not a complete cause of the movement, but only a state of affairs that at a later time, after the signal, when the choice occurs, becomes a part of a complete cause.

7 Trevena and Miller's experiments

(7.1) Also the experiments by Trevena & Miller (2002 and 2010), which implement some of the possible experiments that I mentioned in § 6.1, provide evidence for the thesis that the RP does not cause the movement. The two experiments from 2002 are designed to 'replicate Libet et al.'s [1983] comparison of participants' movement-related brain activity with the reported times of their decisions to move and also the reported times of their decisions of which hand to move.' They designed the experiment more according to what Libet said than to what he did. For example, they really instructed the test persons to move their hand whenever they want to, as opposed to Libet, who frequently wrote that he had told the test persons to move whenever they want to, but who in fact had instructed them to move only when an urge arises. The two experiments from 2010 compared 'the electrophysiological signs before a decision to move with signs present before a decision not to move'. As there are two versions of the second experiment from 2002 and two versions of the first experiment from 2010, there are in total six experiments, which use, in summary, the following instructions given to the test persons:

1. Watch the screen, you will see an L or an R. A while after the letter disappears, a clock with a moving dot will appear. Then, at any time you want to, press the left key if it was an L and press the right key if it was an R. Do so spontaneously, as soon as you feel like it, rather than preplan the movement. Note the position of the dot at the time of the decision to

- go now. (2002, pp. 172–177)
2. Put your two hands on these two keys and press at any time one of them. Note the position of the dot at the time of the decision to move now.
 3. Put your two hands on these two keys and press at any time one of them. Note the position of the dot at the time of your decision of *which hand* to move. (2002, pp. 179–185)
 4. Put your two hands on these two keys. At the start of each trial you will see an L or R, indicating the hand to be used on that trial. When you then after a while hear the tone, tap the key with the required hand as quickly as possible.
 5. Put your two hands on these two keys. ‘At the start of each trial you will see an L or R, indicating the hand to be used on that trial. However, you should only make a key-press about half the time. Please try not to decide in advance what you will do, but when you hear the tone either tap the key with the required hand as quickly as possible, or make no movement at all.’ (Trevena and Miller 2010, p. 449)
 6. ‘When you hear the tone, please quickly tap with whichever hand you feel like moving. Please try not to decide in advance which hand you will use, just wait for the tone and then decide.’ (Trevena and Miller 2010, p. 452)

Results

(7.2) In experiment 1, Trevena & Miller measure also another brain event, the ‘Lateralized Readiness Potential’ (LRP):

‘The LRP measures the degree to which there is more preparation to move one hand than the other, and

it therefore seems to be a more specific measure of motor preparation than the RP, which shows signs of also reflecting a general anticipation of a forthcoming voluntary movement. Clearly, then, a finding that LRP onset preceded conscious decision making would considerably strengthen Libet et al.'s (1983) conclusion that brain processes involved in movement preparation actually do precede the conscious decision to move.' (2002, pp. 171–172)

The result of this experiment: 'The main hand-specific preparation movement starts approximately 300 ms before the movement.' The readiness potential (RP) 'may be real[ly] starting as early as 800 ms before the key press.'⁸ (2002, p. 175) Finally, 'most of the reported decision times were less than 400 ms before the movement'. (2002, p. 177)

(7.3) The conclusion supported to some degree by these measurements is that the RP starts before the conscious decision, and the LRP starts after the conscious decision. The measurement of the decision time is not very precise, because different persons might call slightly different events the decision and because the measurement is difficult. But that the LRP is measured to start after the decision disconfirms Libet's claim that our actions are initiated unconsciously. It does so in the way in which your searching for a cat in a room but not finding one disconfirms the

⁸Trevena & Miller note: 'The onset time of -800 ms is much earlier than the -500 ms reported previously [by Libet et al. 1983] for a RP before a spontaneous voluntary movement. . . . Indeed, visual determination suggests a value of -1300 ms in the present study, and this value is even more discrepant from those reported previously [by Libet].' (2002, p. 175) They do not realize that Libet did not instruct the test persons to move whenever they want to, but to wait for an urge. The difference in RP onset time is probably connected with this difference. In an action out of an urge less preparation in the brain is necessary.

hypothesis that there are cats in the room. If we find that the RP begins before the decision but is only a preparation, and that the LRP does cause the movement but begins after the decision, then we have searched the brain quite thoroughly for unconscious causes of our decision and found that the best candidates are not such causes.

(7.4) In experiments 2 and 3, ‘the RP was significantly negative 2000 ms before the movement. [...] The onset of the LRP is between 300 and 600 ms before the movement.’ (2002, p. 183) ‘The LRP begins earlier for the Hand-report condition [experiment 3] than for the When-report condition [experiment 2]’. (184) ‘The earliest decision of when to move is at about –500 ms, whereas the earliest reported decision of which hand to move is slightly earlier, at about –650 ms.’ (184) So the LRP begins briefly before or briefly after the conscious decision. That the hand-specific LRP begins much later than the RP confirms my thesis that the RP is not a cause of the action but just a preparation. At the time of the RP the action process is not yet on its way. There is at that time no event that is a stage of a causal process directed towards the movement. This is also confirmed by the fact that the RP starts so long before the movement, because it is unlikely that there is such a long time between the initiation of the action process and the beginning of muscular movement. It does not take 2 seconds for a process to go from the brain to the muscle.⁹

(7.5) That the RP here begins so much earlier than in Libet’s experiment, shows (although Trevena & Miller do not note this) that in actions that are really voluntary the RP starts earlier

⁹This point is also a reason to doubt Soon et al.’s interpretation of their experiment that ‘the outcome of a decision can be encoded in brain activity of prefrontal and parietal cortex up to 10 s before it enters awareness’. (Soon et al. 2008, p. 543) A further reason is that they could predict choices only with less than 60 percent accuracy. For a critique of Soon et al. 2008 see Batthyany 2009, pp. 151–156

than in Libet's pseudo-voluntary actions, i. e. movements initiated by urges. This is in line with Libet's observation that in trials with preplanning the RP begins earlier than in trials without preplanning. It confirms the hypothesis that in none of the cases investigated the RP is a cause of the movement, but it is a preparation, i. e. (as explained in § 3.5) an event that later, when the initiating event occurs, becomes a part of the complete cause of the movement. Before a voluntary action the brain gets ready for the conscious decision. The mind tells the brain to get ready because he is considering to make a decision to move. In the case of an urge with preplanning, the preplanning makes the brain get ready. In the case of an urge out of nowhere, without preplanning, that kind of readiness begins later than in the case of an urge with preplanning and later than in the case of a voluntary action, because neither the mind nor an urge tells or causes the brain to get ready.

(7.6) The result of experiments 4 and 5 was that the readiness potential (EEG negativity) 'was present more than 1 s before the tone' in *all* cases. (§ 2.2.2) Even in the cases where the person decided not to move. It grows slowly and continuously until the tone, then it increases sharply and briefly. (See figure 1 on p. 451.) In experiment 5 'the amplitude of the preceding negativity did not vary as a function of whether or not participants actually made a hand movement after the tone.'¹⁰ In both experiments 'movement-related lateralization [LRP] took place only after the onset of the tone, and only when participants actually moved'. (§ 2.2.3) The result of experiment 6 was that the RP began before

¹⁰The authors also conducted a variation of experiment 6 in which the person was free to decide not to move, to move his left hand, or to move his right hand. Also there the result was that in all cases the RP had the same form. (See § 3.2.2.)

the tone, but the LRP began after the onset of the tone.

(7.7) This confirms what I argued in my considerations about Libet's experiment and what Herrmann's experiment has shown. *The RP does not cause the action*, because it starts before the onset of the tone, which is a part of the complete cause of the action. Before the tone there is in the body no process towards the movement.

(7.8) While the RP did not cause the movement, the LRP did. It occurred in all and only those cases where there was movement, and it started after the onset of the tone. But the evidence suggests that it did not start before the conscious decision.

(7.9) Thus far I have investigated only whether the RP or the LRP caused the action, i. e. whether the RP or the LRP from its beginning were a part of a complete cause of the movement. The remaining question is whether in the experiments with a tone the RP or the LRP determine what the person will do when he hears the tone. More precisely, that the RP determined what the person will do when he hears the tone, means that the RP together with states of affairs that obtained from its beginning and together with the hearing of the tone constituted a complete cause of the action. I abbreviate this by saying that the RP was *reaction determining*. The LRP was a good candidate for being reaction determining, but the experiments revealed that it always begins after the tone. That the RP was not reaction determining is proved by the fact that in experiment 5 the RP in the cases where the persons moved had the same onset time and shape as in the cases where they did not move, and by the fact that in experiment 6 in the cases where the persons moved their left hand the RP had the same onset time and shape as in the cases where the persons moved their right hand.

(7.10) I conclude that the experiments by Trevena & Miller constitute strong evidence for the claim that neither the RP nor the LRP cause our actions before the conscious decision or before

we even think about them and that neither the RP nor the LRP are reaction determining. Trevena & Miller conclude rightly that ‘the outcome of the decision (whether to move or not) is not related to the magnitude of either the negativity [the RP] or LRP at the time of the decision.’ (§ 2.3)

8 Conclusion

Our question was whether the RP causes our actions before the conscious decision or before we even think about them, in the sense that the RP from its onset is a part of a complete cause of the movement, i. e. a part of a process heading towards the movement. Libet’s claim that the movements which he investigated were caused by the RP is not supported by his experiment. Therefore also his claim that *in general* our actions are caused by unconscious brain events that precede our decisions is not supported by his experiment. The experiments by Herrmann et al. and by Trevena & Miller provide strong evidence for the thesis that our movements are not caused by the readiness potential, and some support for the claim that our actions are not caused by preceding unconscious brain events, because the RP and the LRP are good candidates for being causes of the actions, but the RP has been found not to cause the actions, and the LRP has been found to begin after the conscious decision. It is now quite certain that the RP is what the name which its discoverers, Hans Helmut Kornhuber and Lüder Deecke, gave to it already in 1965 expresses: it is a ‘Bereitschaftspotential’, i. e. a readiness potential; a state of *readiness*, and not the cause of the action process. It is a part of a state of affairs that can later become a part of the complete cause of a movement. The various experiments are therefore compatible with strong libertarian free will, and they have defeated the some possible empirical defeaters of strong libertarian free will.

The mechanistic belief that our actions are caused by unconscious preceding brain events will never die out. It is not supported by empirical evidence, as John Eccles noted already in his commentary in Libet 1985 (p. 543): ‘*There is no scientific basis for the belief that the introspective experience of initiating a voluntary action is illusory.*’ It may be supported by a priori arguments or by wishful thinking. Maybe future findings will support it, but the existing evidence makes that less probable, as looking for but not finding cats in a room makes it less probable that there are cats in that room. There was no want of criticism of Libet’s claims already when it was published (see the open peer commentary in Libet 1985, pp. 539–566), but nevertheless the belief that he has provided evidence for the mechanistic belief was spread widely. I hope that next time when somebody makes unfounded claims to have found unconscious causes of our actions, the scientific community will be able to communicate more successfully what evidence there is.

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