

Readiness Potentials Do Not Cause Our Actions*

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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 consciously undertake the action. It clarifies what exactly should be meant by saying that the readiness potential causes, initiates, or prepares an action. 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 it. The empirical evidence is compatible with strong libertarian free will. Neither the readiness potential nor the lateralized readiness potential cause our actions.

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

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15 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 Libet's claim *that all our actions have unconscious causes that begin before we consciously undertake them*. In this article I want to show that the experiment does not 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 according to Libet causes 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 suggests: a readiness potential ('Bereitschaftspotential'). I shall proceed by addressing the following points:

- 30 • Summarize Libet's interpretation of his argument.
- What does it mean that a certain event 'caused' or 'initiated' the action?
- Libet's defence of the claim that the RP causes the hand movement.
- 35 • New experiments which show that the RP does not cause the hand movement.

¹Libet described the experiment in Libet, Wright et al. 1982 and Libet, Gleason 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, 2002, number 2, Sinnott-Armstrong and Nadel 2011, Swinburne 2011, L. Deecke and H. Kornhuber 2003, Batthyány 2009. In what follows, publication years refer to Libet's articles unless specified otherwise.

2 The popular interpretation of Libet's experiment

(2.1) Libet conveyed the following picture of his experiment:

40 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)
45 Therefore he gave the test persons a special clock and
asked them to report the time at which they were first
aware of the intention to act. This first awareness is
referred to as 'W'. Libet measured when the muscle
activity and when a certain brain activity, the 'read-
iness potential' (RP), begins. The result was that W
50 begins 200 ms (milliseconds) before muscle activity,
and RP begins 350 ms before W. Therefore 'the voli-
tional process is [...] *initiated* unconsciously' (1999,
p. 47), before the agent consciously undertook it.

55 My question is: Has 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?

60 (3.1) Libet claimed that the RP *caused* and *initiated* the ac-
tions investigated, and that indeed all actions are caused and
initiated by RPs. 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 pres-
ence of the gas before the occurrence of the spark caused the
explosion. But that is not the sense we need for 'The RP caused

65 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 by 'The RP caused the action' 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
70 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 prefer a weaker interpretation:
75 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
80 of the process is directed towards that later event.² With this terminology, Libet's claim that the RP caused the action means that the RP was a part of a state of affairs that was directed towards the movement. The state of affairs did not necessitate the movement because it was possible that something would stop
85 the process, as Libet recognized when he affirmed the possibility of 'vetoing' (Libet 1985, § 4.1).

(3.3) Libet claimed that the actions he investigated and indeed all our actions are *initiated* by an RP.³ We best understand this

²In Wachter 2009, ch. 5 I use the expression 'A stage of the process is the basis of a tendency towards that later event'.

³Libet's claim that the RP 'initiates' the action is contained 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 Libet 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

as an addition to the claim that the RP causes the action. It
90 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*. Before the RP there
was no state of a affairs that was directed towards the movement.
Without the initiating event things would have developed differ-
95 ently, the hand would not have moved (if nothing else caused a
movement).⁴

(3.4) 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,
100 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
occurred, it (as well as some other states) became a part of a
105 complete cause of the movement.

(3.5) Compatibilists (like Gomes 1999 and Schlosser 2012) be-
lieve 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 the reasons) are amongst its causes. There-
110 fore at least for some compatibilists, free will is compatible with
Libet's experiment. However, Libet's claim that all our actions
are caused and initiated by RPs is incompatible with at least
some⁵ strong libertarian theories of free will, for example with

voluntary act is initiated unconsciously' (546).

⁴If 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.

⁵There are views which are sometimes called 'libertarian' but which never-
theless are compatible with Libet's claims and therefore are called 'modest'
(Mele 2006, p. 10; Mele 1995, pp. 211–221; Clarke 2000), 'credible' (Clarke

my view, which goes as follows.⁶ 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. So there is a third way of 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, there is no law-governed process leading from them to the action.

(3.6) Whether we call the agent the ‘cause’ of the choice event 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 cause and that the agent initiates a causal process. Therefore, if Libet’s claim that ‘the volitional process is [...]

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.

⁶See Wachter 2003 and Wachter 2009, ch. 7.

initiated unconsciously' (1999, p. 47) were true for all our actions, then there would be no strong libertarian free will.⁷

4 Libet's defence of the claim that the RP causes the movement

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(4.1) 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 investigate some details of Libet's experiment.⁸ Libet first conducted trials with three persons, 'group 1', and 'after a few months' (1982, p. 323), with three different persons, 'group 2'.⁹ 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 moving round. In the first trials each test person was 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 'self-initiated act' (325).

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(4.2) 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

⁷Other authors who claim that actions involve events that have no preceding cause are Ginet (2007), Lowe (2008, p. 12), Lowe (2013, p. 172), and Meixner (2004, ch. 9).

⁸That the RP does not cause the movement has been argued by: J. 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.

⁹In 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)

the urge to act [move their hand] appear on its own at any time
160 without any pre-planning or concentration on when to act'. (1982,
p. 324) Libet does not tell us why this instruction was added, but
perhaps the reason was that the results varied strongly, or per-
haps 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 exper-
165 iment with group 1, the test persons were asked after each series
'whether they were aware of any pre-planning'. (1982, p. 325)
Apparently, in the trials in which the test persons reported no
pre-planning the RP started later.

(4.3) The results still varied strongly: 'Under our conditions
170 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).

- 175 • Type I RPs: averaged RPs which began more than 700
msec before the hand movement. ('In the more extreme
examples of type I [...], which appeared [...] before intro-
ducing the instruction for "spontaneity", the RP appeared
to have begun rising well before the -1400 msec of the avail-
able pre-event recording time.')
- 180 • Type II RPs: averaged RPs which began 400 to 700 msec
before the hand movement.
- Type III RPs: averaged RPs which began 200 to 350 msec
before the hand movement.

(4.4) Libet presented as the result of his experiment that the
185 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 exper-
iments with type II RPs. This raises questions. If one obtains

190 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
195 trials, there was no pre-planning.

(4.5) It is difficult to find in Libet's articles in which trials the
persons reported pre-planning. Let me quote everything that
Libet says about this:

- 200 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 'pre-planning' is sufficiently
clear at all, it should be easier for the test persons to say after
205 each trial whether there was pre-planning than to say after 40
trials whether there was pre-planning.]
- 210 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 'pre-planning'
in only a minority of the 40 self-initiated acts that occurred in
the series for that averaged RP. The subjective recollection was
215 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)
- 220 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)

- 225 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)
- 230 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 pre-planning experiences for any of the 40 events in the series. Additional experiences of a ‘pre-planning’ phase are associated with type I RPs. (1983, p. 632)
- 235 6. All subjects reported that they could distinguish readily between this awareness [W] and any experience of ‘pre-planning’ that sometimes occurred in acts associated with type I RPs [...]. Awareness of ‘pre-planning’ were completely absent in series associated with type II (or III) RPs. (1983, p. 635)
- 240 7. Actual experiences of ‘pre-planning’ 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 pre-planning], as in type II. (1983, p. 636)
- 245 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 pre-planning or preawareness that it was about to happen. (1983, p. 638)
- 250 (4.6) In none of Libet’s articles we find precise information about how ‘pre-planning’ 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. Libet, Gleason et al. 1983

255 and Libet 1999 do not contain this information. In eight of all
nine series with pre-planning, the RP was of type I. Was in all
series without pre-planning the RP of type II or III? Yes, nearly.
According to quotation 3 (and in accordance with quotation 7),
of 14 series without pre-planning, 9 had RPs of type II, 4 had
260 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 not to preplan and without the question
about pre-planning.) But why then does quotation 4 say that
acts without pre-planning were associated with type II RPs? ‘As-
265 sociated’ here must mean that type II RPs occur always and only
in series without any pre-planning. 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 pre-planning there are not only RPs of type II,
270 but also RPs of type III.

(4.7) Let us then look at the variation of the time of RP onset
in group 2 in all series without any pre-planning, that is, (if we
trust Libet’s statements about where pre-planning was reported)
in all series with RPs of type II or III. Here are the RP onset
275 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
280 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
285 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
290 different people or different cases, or that the measurement is
imprecise.

(4.8) Perhaps we should even leave aside the difference between
trials with pre-planning and trials without pre-planning. Because
it is unclear what a pre-planning before an urge should be, and
295 because it is difficult to obtain exact information about the occur-
rence of pre-planning. Given that all test persons were instruc-
ted to move their hand, all of them must have thought about the
movement in some way, and the boundary between trials with
pre-planning and trials without is surely vague, and the different
300 persons may have treated it differently.¹⁰ If we leave aside the
distinction between trials with pre-planning 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.

305 (4.9) There is another reason why we should take into account
also the trials with pre-planning: If, as Libet claims, the RP
initiated the action process in the cases without pre-planning,

¹⁰Talmi and Frith 2011, p. 128 notes 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 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.'

then it would surely do so also in the cases with pre-planning. Furthermore, Libet's claim is that *all* actions are initiated by RPs. That commits him to holding that also the movements with pre-planning are initiated by RPs. But do the trials with pre-planning perhaps show that in some cases not the RP but the pre-planning and thus a *conscious* event initiates the action?

(4.10) Even if we leave aside the series with type I RPs, 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 by the RP to the hand movement always take the same time. Note that the numbers 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 bigger.

(4.11) What does the fact that in cases with pre-planning 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 RP causes the action, we should expect that the time between the RP and the movement is equal in cases with pre-planning and cases without pre-planning. The pre-planning would not lengthen the time between RP 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 pre-planning the RP begins earlier.

(4.12) 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 RP does not initiate the process leading to the movement. At the onset of the RP there is no such process. It is like the presence of the gas in a room before the explosion caused by someone lighting his pipe: It exists already
345 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.

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

350 (5.1) We can increase 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;
- 355 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 our without a counteracting temptation.

360 (5.2) 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
365 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:

370 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
375 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 "de-
cides" 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 1):

380 Because the RP begins before the signal and the test per-
sons 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,
385 p. 130)

(5.3) 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
390 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.

I conclude that Herrmann et al. (2005) have provided evidence
395 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 § 3.4). 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.

400 6 Trevena and Miller's experiments

(6.1) Also the experiments by Trevena & Miller (2002 and 2010), which implement some of the possible experiments that I mentioned in § 5.1, provide evidence for the thesis that the RP does not cause the movement. The two experiments from 405 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. 410 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 415 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: 420

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 425 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 430 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)

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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.

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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.’ (Judy Trevena and Jeff Miller 2010, p. 449)

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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.’ (Judy Trevena and Jeff Miller 2010, p. 452)

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Results

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

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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 considerable strengthen

460 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.’¹¹ (2002, p. 175) Finally, ‘most of the reported decision times were less than 400 ms before the movement’. (2002, p. 177)

(6.3) The conclusion supported 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 ‘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.

(6.4) 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

¹¹Trevena & Miller note: ‘The onset time of –800 ms is much earlier than the –500 ms reported previously [by Libet, Gleason 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 to this difference. In an action out of an urge less preparation in the brain is necessary.

is slightly earlier, at about -650 ms.' (184) So the LRP begins
485 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 prepara-
490 tion. 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, be-
cause it is unlikely that there is such a long time between the
initiation of the action process and the beginning of muscular
495 movement. It does not take 2 seconds for a process to go from
the brain to the muscle.¹²

(6.5) 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 than
in Libet's pseudo-voluntary actions, which are in fact movements
500 initiated by urges. This is in line with Libet's observation that
in trials with pre-planning the RP begins earlier than in trials
without pre-planning. 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 § 3.4) an event that
505 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 it is considering to make a decision to
move. In the case of an urge with pre-planning, the pre-planning
510 makes the brain get ready. In the case of an urge out of nowhere,

¹²This 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 Batthyány 2009, pp. 151–156

without pre-planning, that kind of readiness begins later than in the case of an urge with pre-planning 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.

515 (6.6) 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
520 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.’¹³ In both experiments ‘movement-related lateralization [LRP] took place only after the onset of the tone, and only when participants actually
525 moved’ (§ 2.2.3). The result of experiment 6 was that the RP began before the tone, but the LRP began after the onset of the tone.

(6.7) This confirms what I argued in my considerations about Libet’s experiment and about what Herrmann’s experiment has
530 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.

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

(6.9) 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

¹³The 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.)

540 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
545 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
550 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
555 their left hand the RP had the same onset time and shape as in
the cases where the persons moved their right hand.

(6.10) 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 and that
560 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)

7 Conclusion

565 Our question was whether the RP causes and initiates our
actions before the conscious decision, 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 that is heading towards the movement.
Libet’s claim that the movements which he investigated were
570 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 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 perhaps future findings will support it, but the existing evidence makes that less probable. 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 false belief that he has provided evidence for the mechanistic belief was spread widely.

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