



ELSEVIER

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Commentary

Preparing to move and deciding not to move[☆]

Gilberto Gomes^{*}

Universidade Estadual do Norte Fluminense, Laboratory of Cognition and Language, R. Lopes Quintas 100-605-1, 22460-010 Rio de Janeiro, Brazil

ARTICLE INFO

Article history:

Available online 15 January 2010

Keywords:

Conscious decision
Cortical movement preparation
Free will
Libet
Readiness potential
Voluntary movement

ABSTRACT

A commentary is given on Trevena and Miller (2010). The comparability of their experimental task and of the potential they recorded with those used and recorded by Libet, Gleason, Wright, and Pearl (1983a) is questioned. An interpretation is given for the similarity of event-related potentials recorded when subjects decided to move and when they decided not to move.

© 2009 Elsevier Inc. All rights reserved.

Trevena and Miller (2010) present an interesting experimental study of the neural correlates of volition and motor action. They studied the electrophysiological correlates of a decision about whether or not to make a movement at an indicated moment. Following the method introduced by Kornhuber and Deecke (1965) and used by Libet, Gleason, Wright, and Pearl (1983a); Libet, Wright, and Gleason (1982, 1983b), they averaged EEG tracings obtained before and after subjects made a conscious decision involving a motor act. Their results are brought to bear on Libet's conclusion that there is an unconscious initiation of voluntary motor acts. This conclusion was based on Libet's finding that a specific neural activity (the earlier part of the readiness potential, RP) was already present before the time that he identified as being the moment of the subject's decision (Libet, 1985; Libet et al., 1983a). Libet's method of timing the intention to move is questionable (Gomes, 1998; Gomes, 2002a; Gomes, 2002b), but the mere facts that the RP is relatively long and subjects were instructed to move immediately after the decision may be sufficient to justify the conclusion about unconscious initiation (Gomes, 1998; Gomes, 1999). Since in Trevena and Miller's (2010) experiments no difference was found in the neural activity preceding the choice to move or not to move, the authors claim that Libet's conclusion is not warranted.

However, the following two questions must be addressed. First, is the subject's decision involved in the present study really comparable to the one studied by Libet? Second, is the neural potential registered in this study similar to the one recorded by Libet? A negative answer to these questions would certainly cast doubt on the relevance of Trevena and Miller's study, interesting as it is, on the question of the unconscious initiation of action.

As regards the first question, we should ask what is to count as a *spontaneous* decision. In Libet's experiments, subjects spontaneously decided *when* to make a given voluntary movement (within a certain time window). By contrast, in Trevena and Miller's (2010) experiments, the moment of the decision was determined by the experimenter. In their words, "participants were instructed to make the spontaneous decision only when they heard a temporally-unpredictable tone, and then either tap a key quickly or to make no movement at all".

[☆] Commentary on Trevena, J., & Miller, J. (2010). Brain preparation before a voluntary action: Evidence against unconscious movement initiation. *Consciousness and Cognition*, 19, 447–456.

^{*} Tel.: +55 21 2294 1931.

E-mail address: ggomes@uenf.br

A different kind of spontaneity is therefore involved here. The decision can no doubt be called 'spontaneous', since it was not predetermined that the subject should make the movement or refrain from making it. However, the moment of initiating the action was not spontaneous. Thus, it can hardly be seen how the results obtained here can be relevant for the question of the *spontaneous initiation* of a movement, that is, of the decision to make a movement at a moment which was not predetermined, but is determined by the subject herself.

Concerning the second question, we must look at the experimental results obtained. Trevena and Miller (2010) state: "From the EEG activity, Libet et al. extracted a movement-preceding negativity called the 'readiness potential' that they assumed was a specific reflection of preparation to make a voluntary movement" and "Their argument is weakened by the current finding that EEG negativity prior to a decision to move does not differ from that before a decision not to move". It appears, though, that the negativities obtained by the two experimental paradigms are quite different. This is clearly seen in comparing Trevena and Miller's Figs. 1 and 2 with Libet, Wright, and Gleason's (1982) Fig. 2, Libet et al.'s (1983a) Fig. 2, Libet, Wright, and Gleason's (1983b) Fig. 2, or Libet's (1985) Fig. 1.

The negativity that precedes the decision in Trevena and Miller's experiments is small and develops very slowly. The negativity that precedes freely-initiated movements in Libet's experiments is the RP, a distinct, much larger and less slowly developing waveform. The two negativities differ in amplitude and in time course. The one recorded by Trevena and Miller scarcely reaches $-2 \mu\text{V}$ while the RP recorded by Libet may easily reach $-10 \mu\text{V}$. The former increases smoothly and continually, in linear form, since the beginning of the recording (more than 2500 ms), while the latter can be clearly distinguished from the tracing preceding it and begins only 550 ms on average prior to movement onset (Libet et al., 1983a, p. 636). The RP is much more similar to the waveform that appears *after* the tone that signals the moment where the decision should be made.

To appreciate the differences between the two experimental paradigms, a closer look is needed into the nature of the tasks involved in them. In Libet's, subjects were asked to perform a predetermined act at a moment of their own decision. Since they were asked to perform the movement immediately after deciding to do so, a relatively long neural preparation preceding the movement might indicate that this preparation was unconsciously initiated (Gomes, 1998; Gomes, 2002a; Gomes, 2002b). In Trevena and Miller's, by contrast, subjects were asked to attend to an auditory tone (presented at an unpredictable moment within a time window), and to decide at this moment whether they would perform a given movement or not. Such conditions are similar to those that elicit the potential known as the contingent negative variation (CNV) (Walter, Cooper, Aldridge, McCallum, & Winter, 1964). The appearance of the clock on the screen may be considered as the warning stimulus and the auditory tone as the imperative stimulus of a CNV experiment. The negativity preceding the tone can thus be seen as a CNV.

Trevena and Miller (2010) discuss CNVs, stressing that they do not merely reflect an anticipation of a sensory stimulus, but are sensitive to motor response preparation. They cite Brunia (2003) who states that "the CNV is also a movement-preceding negativity (MPN), just as the Readiness Potential (RP)". However, the CNV may also be present in the absence of any movement, actual or intended, so it is not just a *movement*-preceding negativity. Moreover, even when movement preparation is present and increases the amplitude of the CNV, the experimental situation and the characteristics of the potential are quite different from those of the RP. Concerning the former, we have the absence of the warning and imperative stimuli in the RP situation. Concerning the latter, Grünewald, Grünewald-Zuberbier, Netz, Hömberg, and Sander (1979) found similarities between the late CNV and the RP, but differences as regards the early CNV; Cui et al. (2000), using high resolution DC-EEG techniques, found important differences between the late CNV and the RP; and Hamano et al. (1997), using implanted subdural electrodes, showed that CNV and RP have a different distribution of brain generators.

Trevena and Miller (2010) state that the negativity preceding the tone "seems to indicate a general ongoing involvement of the participant with the task—perhaps anticipation of the tone". This seems reasonable, but does not apply to the RP, which does not involve any expectation of an imperative stimulus and is not started by any warning stimulus.

Since there are important differences between the negativities that precede the decision in the two experimental series and also between the psychological situations of decision-making involved in each, it is highly questionable whether Trevena and Miller's experiments do in fact provide evidence against the unconscious initiation of movements performed at a spontaneously determined moment.

I believe that one of the most interesting results in Trevena and Miller's (2010) study concerns, not the negativity that precedes the tone, but the potential that follows it, and particularly the fact that this potential (at the vertex) is very similar whether the subject chooses to move or not to move. This finding is similar to what was found in Libet's 'veto' experiments. In these, subjects had to prepare to perform a movement at a preset time and "veto" this intention 100–200 ms before this time (according to the clock they were observing) (Libet et al. 1983b). This elicited an RP, although no movement occurred.

To see why they are similar, let us proceed in our examination of the subjects' task in Trevena and Miller's experiment. They are asked to wait for the tone, and when it is presented, either to make the movement (in the "always move" series) or to choose whether to make the movement or not (in the "sometimes move" series). Thus, before the tone is presented, the subject is waiting for it and ready to start the neural activity that will directly cause the movement. Then the tone is presented (zero time on the EEG tracings). This does not mean that the subject has consciously perceived the tone at zero time. Consciousness takes some time to be accomplished. Neither should it be supposed that the subject needs to be conscious of the tone to decide whether to move or not.

In the 'sometimes move' series, subjects most likely have already prepared themselves to either start the movement or not. In order to be prepared to either start the movement or not, they must be prepared to start the movement. Therefore, the

early neural processing of the auditory tone can hardly fail to automatically trigger the initiation of the neural events leading to the movement, which will then be inhibited or not, according to the subject's decision. This inhibition of the neural events leading to the movement is probably similar to what occurred in Libet's veto experiments.

Trevena and Miller's subjects were asked to try not to decide in advance whether they would move or not. As suggested above, however, such a simple choice should not be supposed to require the intervention of consciousness. It may be made automatically, upon detection of the tone, since it was consciously planned in advance (even if the subject did not consciously plan which option to choose).¹ It may thus be supposed that the activation (and inhibition, if it is the case) of the neural preparation for movement, after the tone, may occur even before the subject becomes conscious of the tone.

When the subject chooses not to move, the presence of a neural potential usually associated with movement preparation is in striking contrast to the absence of movement. Movement is absent in reality, but the neural potential seems to be related to the presence of movement in the subject's mind, as one of the options between which she is choosing. The subject thus seems to be preparing to move, deciding not to move and consequently inhibiting this readiness to move.

Future studies might investigate interesting variations in the experimental set-up. For example, one could have a 'decide in advance' control situation, in which subjects would be instructed to decide at the beginning of the trial whether they would move or not at the tone. Another control situation might have the subjects decide at the tone, but only move (if they had so decided) after a delay. These variations might produce interesting effects on the event-related potential, both before and after the tone.

References

- Brunia, C. H. M. (2003). CNV and SPN: Indices of anticipatory behavior. In M. Jahanshahi & M. Hallett (Eds.), *The Bereitschaftspotential: Movement related cortical potentials* (pp. 207–227). New York: Kluwer.
- Cui, R. Q., Huter, D., Egkher, A., Lang, W., Lindinger, G., & Deecke, L. (2000). High resolution DC-EEG mapping of the Bereitschaftspotential preceding simple or complex bimanual sequential finger movement. *Experimental Brain Research*, *134*(1), 49–57.
- Gomes, G. (1998). The timing of conscious experience: A critical review and reinterpretation of Libet's research. *Consciousness and Cognition*, *7*, 559–595.
- Gomes, G. (1999). Volition and the readiness potential. *Journal of Consciousness Studies*, *6*(8–9), 59–76. Reprinted in Libet, B., Freeman, A., Sutherland, K. (Eds.). (1999). *The Volitional Brain*. Thorverton, UK: Imprint Academic.
- Gomes, G. (2002a). Problems in the timing of conscious experience. *Consciousness and Cognition*, *11*, 191–197.
- Gomes, G. (2002b). The interpretation of Libet's results on the timing of conscious events: A commentary. *Consciousness and Cognition*, *11*, 221–230.
- Grünewald, G., Grünewald-Zuberbier, E., Netz, J., Hömberg, V., & Sander, G. (1979). Relationships between the late component of the contingent negative variation and the Bereitschaftspotential. *Electroencephalography and Clinical Neurophysiology*, *46*(5), 538–545.
- Hamano, T., Luders, H. O., Ikeda, A., Collura, T. F., Comair, Y. G., & Shibasaki, H. (1997). The cortical generators of the contingent negative variation in humans: A study with subdural electrodes. *Electroencephalography and Clinical Neurophysiology*, *104*(3), 257–268.
- Kornhuber, H. H., & Deecke, L. (1965). Hirnpotentialänderungen bei Willkürbewegungen und passiven Bewegungen des Menschen: Bereitschaftspotential und reafferente Potentiale. *Pflügers Archiv für die gesamte Physiologie des Menschen und der Tiere*, *284*, 1–17.
- Libet, B. (1985). Unconscious cerebral initiative and the role of conscious will in voluntary action. *Behavioral and Brain Sciences*, *8*(4), 529–566.
- Libet, B., Wright, E. W., Jr., & Gleason, C. A. (1982). Readiness-potentials preceding unrestricted 'spontaneous' vs. pre-planned voluntary acts. *Electroencephalography and Clinical Neurophysiology*, *54*, 322–335.
- Libet, B., Gleason, C. A., Wright, E. W., Jr., & Pearl, D. K. (1983a). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). *Brain*, *106*, 623–642.
- Libet, B., Wright, E. W., Jr., & Gleason, C. A. (1983b). Preparation- or intention-to-act, in relation to pre-event potentials recorded at the vertex. *Electroencephalography and Clinical Neurophysiology*, *56*, 367–372.
- Trevena, J., & Miller, J. (2010). Brain preparation before a voluntary action: Evidence against unconscious movement initiation. *Consciousness and Cognition*, *19*, 447–456.
- Walter, W. G., Cooper, R., Aldridge, V. J., McCallum, W. C., & Winter, A. L. (1964). Contingent negative variation: An electric sign of sensorimotor association and expectancy in the human brain. *Nature*, *203*, 380–384.

¹ Incidentally, it may be noted that they were also instructed to make a key-press only about half the time (Trevena & Miller, 2010). This instruction seems to be in conflict with the one just mentioned. If the subject is to make a quick decision after the tone, how is she to guarantee that each of the two alternatives will be chosen about half the time without any preplanning? Apparently, at least in some of the trials the subject would have to plan a future choice on the basis of the relative frequency of previous ones.