Self-initiated versus externally triggered movements. I. An investigation using measurement of regional cerebral blood flow with PET and movement-related potentials in normal and Parkinson's disease subjects

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Abbreviation: SMA = supplementary motor area

We have read with interest the article, 'Self-initiated versus externally triggered movements I. An investigation using measurement of regional cerebral blood flow with PET and movement-related potentials in normal and Parkinson's disease subjects' by Jahanshahi et al. (1995). The authors argue that their results substantiate the assumption that the supplementary motor area (SMA) contributes to the 'early' Bereitschaftspotential. We wish to raise some methodological points and propose a different interpretation of the results.

(i) The term 'Bereitschaftspotential' should be used in an unequivocal sense. It was originally used for a parietally and centrally negative, frontally positive scalp potential appearing before self-initiated movements (Kornhuber and Deecke, 1964; Deecke et al., 1969). Therefore it is confusing as to why the authors also applied it to the electrical potentials recorded in advance of externally triggered movements. These potentials are not movement-specific since they can also be recorded in advance of an anticipated stimulus and were named contingent negative variation (Walter et al., 1964).

(ii) The argument of the authors is based upon the statistical evaluation of the amplitude of the 'early' Bereitschaftspotential. For several reasons this is a questionable procedure. First, the division of the Bereitschaftspotential into an 'early' and a 'late' phase seems to be self-evident considering the different steepness of this potential during these two epochs. However, there is no evidence that different physiological processes or different brain areas cause these two epochs of the Bereitschaftspotential. Microelectrode studies (Wiesendanger and Wise, 1992) and intracranial recordings in humans (Ikeda et al., 1992) showed no difference in timing of pre-movement activity in different motor areas. The steepness of the two postulated parts of the Bereitschaftspotential are significantly correlated at various scalp electrodes (Bötzef et al., 1993) suggesting a common origin of these potentials. As an alternative to the arbitrary distinction of 'early' and 'late', the time course of the Bereitschaftspotential can be conceived as an exponential waveform with reduced amplitude in Parkinson's disease patients. Secondly, in the case of the externally triggered movements a distinction into two phases is totally arbitrary since these potentials usually display no different steepness. Thirdly, instead of determining the steepness of the two parts of the Bereitschaftspotential, the authors reported that the distinction into 'early' and 'late' was made by 'four scientists'. However, they did not report what criteria these scientists used and whether they were blinded as to the diagnosis of the subject under consideration. Regarding the noise contained in the data this subjective measurement can introduce a considerable bias into the data which then were processed statistically.

(iii) With regard to the patients, the authors report a reduced blood flow in the SMA and a reduced 'early' Bereitschaftspotential in self-initiated movements. This was taken as an argument for a contribution of the SMA to the 'early' Bereitschaftspotential. This argument is difficult to follow since the electrode overlying the SMA (Cz) did not show an amplitude reduction. Furthermore there is no plausible explanation why, in the case of externally triggered movements, the SMA of the patients is capable of generating a 'normal early Bereitschaftspotential'. We suggest another interpretation of the reported findings which follows Goldberg's (1985) description of a lateral and a medial motor system. We suggest that both primary motor cortices are the main sources of the pre-movement potentials reported in this paper. Dipole analysis algorithms have proven that this is a feasible explanation for the Bereitschaftspotential (Toro et al., 1993; Bötzef et al., 1993). In the case of the externally triggered movements the activation of the primary motor cortex is initiated and maintained by the lateral premotor cortex. These structures seem to be largely intact in Parkinson's disease resulting in a normal pre-movement potential. When movements have to be self-initiated, the SMA activates the primary motor cortex, which generates the Bereitschaftspotential. Due to a probable underfunction of the SMA in Parkinson's disease, this Bereitschaftspotential is
reduced. However, at the electrode Cz, the electric fields of both motor cortices overlap and the amplitude reduction is less obvious. The electric activity of the SMA itself is unlikely to be recordable at the scalp since both SMAs face each other, which results in a cancellation of their electric fields when they are activated synchronously (Lang et al., 1991).

The authors clearly demonstrated with the PET method that movement preparation and generation involves multiple brain areas. In contrast, recording the Bereitschaftspotential provides much less information. Therefore, an important conclusion from this report is that the Bereitschaftspotential, wherever its origin may be, is not a suitable instrument to investigate the complexity of the processes underlying movement preparation and generation.

References


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Reply
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Abbreviations: BP = Bereitschaftspotential; SMA = supplementary motor area

We are pleased that Böttzel and Schulze found our paper of interest. We will address the points raised in their letter.

(i) We agree that there is a need for more unequivocal use of the term ‘bereitschaftspotential’ (BP). Our use of the generic term ‘movement-related potentials’ in the title and at many points in the manuscript was partly motivated by the recognition that while, in the self-initiated condition, the movement-preceding negativity is a BP, there is less agreement about whether the same is true of the negativity found in the externally triggered condition. However, to allow comparison of movement-related potentials across self-initiated and externally triggered conditions and to avoid confusion arising from use of different terminology we referred to both with the shorthand term ‘BP’. Furthermore, the use of the term ‘contingent negative variation’ would be inappropriate, because in neither of the externally triggered conditions in our study was the onset of the imperative stimulus completely predictable across trials and we did not use the warned reaction times (S1–S2 paradigm) normally employed to record contingent negative variations. Even with such a paradigm, some have suggested that the late contingent negative variation reflects a BP and not just simply expectancy of the imperative stimulus (Roehringa and Gaillard, 1983).

In fact, we would like to take Böttzel and Schulze’s point further and suggest that use of unequivocal nomenclature only becomes feasible when we gain a better understanding of the processes that contribute to the development of surface negativity. Intention to act, motor preparation, effort, expectancy, stimulus anticipation are some of the processes that may be involved. What is necessary, in addition to unequivocal terminology, is clarification of which of these underlying processes contribute to development of surface negativity with particular motor tasks. We discussed the possible processes involved in the self-initiated and externally triggered movements used in our study (p. 926). In self-initiated movements, motor preparation and intention to act...