Preliminary Observations on the Effects of Response Parameters on Pre-response Potentials

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This is an interim report of an investigation into the effects which response parameters may have on the slow pre-response cortical negativity which is sometimes labelled the Readiness Potential (RP). It seemed to us that if these potentials reflect preparatory activity by the motor control centres, in anticipation of the execution of a response, then the characteristics of the anticipated response should affect the amplitude, or the cortical distribution of the potentials. It is also possible that these potentials are CNVs recorded over intervals defined by intra-subject signals rather than by external stimuli. It has been demonstrated that CNVs can be recorded in the absence of a motor response (i.e. Donchin *et al.*, 1972); it is difficult therefore to view CNVs as solely reflecting motor preparedness. Our intention has been to conduct a factorial experiment varying both the cognitive and the motor parameters of the task, and thus to determine the effects of such variations on pre-response potentials. At this time only part of the data has been collected and analysed.

METHOD

This investigation had its genesis in an attempt to derive information relevant to the interpretation of the RP from data collected in a different investigation (Donchin *et al.*, 1973b). In a study focused primarily on P300 we presented *Ss* with sequences of choice RT trials. *S* was to press a button with either his right or left thumb, depending on the outcome of the trial. Outcomes were presented in different sequences, in some series the outcome being completely predictable, in others completely unpredictable. If the outcome is predictable the responding hand is also predictable. A 'motor' interpretation of the pre-response potentials should predict a different cortical distribution of pre-response potentials during predictable and unpredictable series. We reasoned that when *S* knows the hand he is to respond with preparatory activity should appear unilaterally. When both hands may have to respond a more symmetrical distribution should be expected. This however was not the case. The distribution of the two potentials along the interaural line was the same for predictable and unpredictable series (*see* Donchin *et al.*, p. 76). However, the microswitch depressed by *Ss* required a force of about 450 grams for a full depression. It was possible (Otto, personal communication) that the 'motor' characteristics of these potentials may be brought out by requiring a more forceful response. It is in the attempt to resolve this issue that we developed response-devices with which the parameters of the response could be adequately measured. Two different devices were constructed and will be discussed separately.

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Series I: Work and the Slow Potential (squeezing a spring)

Response device: Two padded vertical poles protruded from the subject's arm rest. The subject held his palm against the proximal pole and his fingers around the more distal pole. The two poles were attached to a heavy steel spring. The distal pole could be moved towards the proximal pole thereby depressing the spring. A microswitch was installed in such a way that it could be tripped by the moving vertical pole. A successful squeeze was defined by the tripping of the microswitch. By varying the position of the microswitch with respect to the moving pole the force with which *S* was required to squeeze could be varied. Of course, force requirements in this device were confounded with the displacement requirements. Thus, strictly, we were varying the *work* required of the *S* rather than the *force* which he had to generate.

Ten *Ss* were paid for participating in the experiment. Beckman cup electrodes (silver–silver chloride) were placed at C_z, O_1, C_4, C_3, T_4, T_3. *Ss* were instructed to squeeze on the bars until they heard the audible click of the microswitch. An intersqueeze interval of 3–4 sec was maintained. Each *S* generated three 50 trial series with each of three different work levels. In addition, they each pressed 50 times with each thumb on the button press device used in our previous experiments.

RESULTS

The results obtained with this primitive response gadget were rather inconclusive. They are discussed here mainly because of the results we obtained with a more sophisticated device. We note here two aspects of the data. The records for C_3 and C_4 were superimposed and the degree of asymmetry determined by visual inspection. When *S* responded with the right hand we found an asymmetry in 1 out of 9* *Ss* for the button press, 4 out of 9 for the lowest work level, 4 out of 8 for the medium work level and 5 out of 7 for the hardest level. Similar results were obtained for the responses with the left hand. The potentials were larger at the contralateral hemisphere. The work level requirement had a clear effect on the amplitude of the components. The harder, and more displaced, the squeeze, the larger were the amplitudes of the potentials recorded at C_3 and C_4. However, the data showed considerable intersubject variability and it would be difficult to accept these as more than preliminary results.

There were many evident difficulties in the technique described above. The force level requirements could not be accurately set and calibrated. The force requirements were confounded with the displacement as well as with the time required by *S* to respond. We have therefore developed a system without these drawbacks.

Series II: The Electronic Dynamometer

Response device: Two metal hand grips were each connected to an LVDT force transducer (Daytronic Model 152 A). These transducers provide a precise and high resolution measure of the force applied to them. The maximal displacement of the transducer is 0·001 in and the displacement is independent of the applied force. The transducer provides a continuous output proportional to the applied force and is energised electronically. It provides a continuous display of

*Data from subjects generating excessive eye movements were discarded. Hence the unequal number of subjects.

its output as well as allowing a rapid setting of force limits which activate a Schmitt trigger. One of the problems we encountered in the use of the previous grip device derives from the fact that *Ss* differ widely in the ease with which they generate different force levels. We now define force levels not in terms of their absolute level but rather as percentages of the maximal force level a *S* can generate at the beginning of a session. Having determined for each *S* his maximal level he was then tested at 25 per cent, 50 per cent and 75 per cent of this level.

Ss (12, all male, 7 right handed) sat in a comfortable chair viewing an illuminated circle in a Tachistoscope. The circle was superimposed on an illuminated square which was always on. Whenever *S* reached the force level set for a given series the illuminated circle disappeared. Thus from *S*'s point of view his task was to operate a switch extinguishing the circle. (An equivalent series was subsequently run in which no such feedback was provided.) Scalp electrodes were placed at C_Z, C_3, C_4 as well as 2 and 4 cm lateral, and 4 cm anterior to either side of the vertex. Recording was referential to linked ear electrodes. In addition the EOG and EMGs from either the left or the right arm were recorded. All data were recorded with Brush amplifiers (band pass 0·1–30 Hz) and analysed by an IBM 1800 computer. Trial series of 50–100 trials each were obtained for each hand, for each of three force levels.

RESULTS

All conclusions at the present are based on visual inspection of superimposed records averaged for each *S* and obtained from right-handed *Ss* only. With these restrictions the results may be very simply summarized. We find that the amplitude over the left motor cortex of the potentials (all components) are larger than the corresponding potentials obtained over the right motor area, when *S* responds *with his right hand.* This asymmetry between the hemispheres disappears when *S* responds with his left hand. The above result appears at all force levels.

In general, we find that the force level has no effect on the amplitude of the potentials, the amplitudes at all three levels used, for each of the right-handed *Ss* is identical. We also note that the presence or absence of the feedback stimulus at the termination of the movement has no immediately obvious effect on the potentials.

DISCUSSION

As the data from left-handed *Ss* has not yet been analysed it is not possible to tell if the asymmetry observed for the right hand response is characteristic of right hand responses in general or is associated with the response of the dominant hemisphere. Either way, the result will have important implications for the interpretation of these slow potentials. Equally puzzling is the fact that force level fails to affect the potentials, particularly since work-levels did affect the potentials in our first series of *Ss*. Due to the crudeness of the initial response device the early data must be accepted with caution. A systematic investigation of the effects of displacement and force pre-response potentials is required. Finally, we have still to reach the stage of our study in which the force level, and the work level, are examined in a CNV producing paradigm, namely when *S* operates the dynamometer in response to an imperative stimulus, preceded by a warning stimulus.

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