LOW-LEVEL ELECTRICAL CURRENTS AND BRAIN INDICATORS OF BEHAVIORAL ACTIVATION

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Among the neural systems involved in the regulation of behaviour, Pribram and McGuinness[4] distinguish "arousal" (phasic responses to environmental input), "activation" (tonic physiological readiness to respond) and a coordinating activity demanding "effort".

There exists some evidence that latency, topography and especially functional properties of slow brain potentials recorded during the interval between a warning and a subsequent imperative stimulus that requires a response from the organism might reflect the operation of these neural systems, so that they could be operationally defined and studied in terms of these electrical brain correlates. Some authors[2,6] have presented evidence that at least two components could be discerned in the slow brain potentials recorded at the vertex during the interval between two stimuli, when the second is an indication for action (reaction-time task). The first component would be associated to the warning signal, the second to the preparatory state developed before the response. Although this work has been done minimizing the temporal overlap and with interstimulus intervals of 4 sec and more, it indicates a temporal pattern of involvement of the arousal-activation systems that might be studied even at shorter interstimulus intervals. This feature might be relevant for testing experimental manipulations of arousal and activation.

On the basis of some neurophysiological data and theoretical considerations many authors have tried to explore the effects of low level d-c eletrical stimulation upon the behaviour of animals and man[1]. Main issues in this research have been the demonstration of a possible specific effect of the polarity of current flow and the electrical field thus created (anodal and cathodal polarization) and the therapeutic relevance this effect might have in nervous function.

This work attempted to study the effect of weak eletrical polarization of the brain upon the slow brain potential correlates of arousal and activation.

METHODS

Five human volunteers matchel with respect to age, education and personality scores were instructed to respond to a visual stimulus preceded in 1 sec by a warning auditive signal (1000 Hz, 100 msec tone), while electrical activity of the brain was

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Acknowledgments — This work was supported by the University of Chile, Project 3138.

recorded using Ag-AgCl disc electrodes in the vertex-mastoid derivation, 5-sec time constant and computer sampling at intervals of 20 msec during each trial, usually terminated by the subject's response. Eye movement potentials were monitored and cancelled when present. Average slow potentials were obtained in blocks of 20 trials from activity during the interstimulus interval. Weak electrical polarization was applied between head and arm electrodes at a fixed intensity of 300 microamp. using a double-blind and cross-over design. Period of application did not exceed 20 min. for each subject, who received pseudopolarization (PP, no current flow, placebo), anodal (head positive) and cathodal (head negative) polarization on different days. When current was applied, a period of post-effects was also included in order to assess long-term effects of d-c polarization.

RESULTS

Three measurements were obtained. Table 1 shows the mean peak amplitude under the different conditions averaged accross all subjects. It can be seen that anodal and cathodal polarization enhanced the maximum amplitude of vertex negative shifts when compared to control conditions, values returning to normal during the post-effects period in both cases. These differences were not statistically significant.

Condition	Mean (uV)	SEM	Range
Basal (B)	4.56	0.53	1.4 — 7.4
Pseudopol.(PP)	5.35	0.69	3.2 — 9.8
Anodal (P+)	6.01	0.97	2.5 — 13.3
Post anod. (PE+)	5.01	0.51	2.5 — 6.8
Cathodal (P—)	6.80	0.83	2.1 — 10.1
Post cathod. (PE—)	5.01	0.71	2.7 — 9.8

Table 1 — Peak vertex slow potential amplitude under different conditions: Mean obtained on the basis of two average values for each of the five subjects (N=10), negative amplitude; SEM=standard error of the mean.

The interstimulus interval was divided into a pre-maximum portion and a post-maximum one, depending upon the latency at which maximum amplitude was achieved. The electrical signal was then analysed computing the integral (or area under the curve) for these two portions separately. Results are depicted in table 2 for total, pre-maximum and post-maximum area. Analysis of variance based on these parameters with entries subjects x conditions rendered significant F ratios for between-conditions variability only for the post-maximum segment ($F = 2.66$; df. $= 5/30$; $P \leq 0.05$). The other parameters rendered non significant F ratios. It can be seen that anodal polarization produced the most marked and enduring effect when compared to basal and control (pseudopol.) conditions.

Reaction time also changed as a result of polarization. From the control value of 234.9 msec it dropped to 209.9 with anodal and was lengthened to 289.1 msec with cathodal polarization, a trend not statistically significant but suggestive of opposite effects of anodal and cathodal polarization on this parameter.

Latencies of peak slow potential amplitude, with respect to the warning stimulus, were not significantly different under anodal or cathodal polarization.

Condition	Total area		Pre-max. area		Post-max. area	
	Mean	SEM	Mean	SEM	Mean	SEM
B	1.71	0.25	1.14	0.18	0.57	0.10
PP	1.41	0.17	0.90	0.096	0.51	0.085
P+	2.03	0.377	0.90	0.113	1.13	0.26
PE+	1.78	0.342	0.88	0.177	0.90	0.229
P—	1.85	0.335	0.86	0.20	0.99	0.219
PE—	1.43	0.242	0.75	0.138	0.68	0.168

Table 2 — Area values (uV sec) for different conditions: SEM = standard error of the mean. All values refer to negative area and each mean is based on two values per subject (N=10)

DISCUSSION

The sequential involvement of arousal and activation systems during the interstimulus interval of a reaction-time task, demonstrated by other workers using long intervals, prompted us to explore brain electrical activity sampled closer to the warning signal (reflecting physiological responses to input, i.e. arousal) and closer to the imperative one (reflecting readiness to respond, i.e. activation). The assumption has been that even at the 1 sec interval employed the functional properties of those systems might still be retained. Viewed in this perspective, three main conclusions can be derived from this work. First, polarization seems to have some physiological effect on neural systems, even if this might not be observable in overt behaviour. Second, polarization exerts this effect increasing negativity of slow brain potential shifts, considered to reflect increased excitability of CNS [3,4], irrespective of polarity employed, and acting upon the segment closer to the imperative signal, thought to reflect activation, or readiness to respond, rather than orienting. This receives support from other studies [1]. Third, although not demonstrated in brain activity, anodal and cathodal polarization did modify reaction time in opposite directions, indicating that vertex slow potentials and reaction time are dissociable processes reflecting different underlying mechanisms [5].

These results support the heuristic validity of the constructs of arousal and activation, as defined in the present context, in studies of physiological correlates of behaviour. They suggest further that possible therapeutic efficacy of low-level d-c polarization should be for in activation or preparatory systems, a derangement of which is undoubtly involved in some forms of nervous disorders.

SUMMARY

Distinguishing between slow brain potential correlates of arousal and activation on the basis of their functional role and temporal involvement during a reaction-time task, data are presented which suggest that weak electrical polarizing currents applied to the head in human subjects modify predominantly activation indicators rather than arousal ones.

RESUMEN

Corrientes elétricas de baja intensidad e indicadores cerebrales de activación conductual.

Distinguiendo entre potenciales lentos cerebrales indicadores de "arousal" y "activación" sobre la base de su rol funcional y compromiso secuencial durante una tarea de tiempo de reacción se presenta datos que sugieren que corrientes polarizantes débiles aplicadas céfalicamente en sujetos humanos modificam predominantemente indicadores de "activación" más bien que de "arousal".

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