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Electroencephalographic Laterality Changes During Human Sexual Orgasm

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Left and right parietal EEGs were recorded while seven subjects experienced sexual climax through self-stimulation. EEG data were quantified by continuous cumulated measurements of the integrated areas of EEG recording during successive 1-sec epochs. In eight out of 12 experiments, this measure revealed a statistically significant change in laterality. Controlled replications with two of the original subjects obviated the possibility that two potential sources of artifact (hand used for masturbation and gross body movements) accounted for the changes. While previous research has focused on vasomotor and myotonic indices of sexual response, this study demonstrates the significance of brain phenomena in sexual orgasm.

KEY WORDS: orgasm; masturbation; brain; sex; electroencephalogram.

INTRODUCTION

Previous attempts to measure the physiological changes associated with human orgasm in the laboratory have focused on changes in the autonomic nervous system and peripheral musculature (Bartlett, 1956; Masters and Johnson, 1966; Fox and Fox, 1969, 1971). Such a research orientation has produced a peripherally focused account of the process of sexual climax, in which blood flow changes and muscular contractions are commonly viewed as the crucial determinants of human orgasm. There is no doubt that some peripheral measures reliably correlate with the early stages of sexual arousal (Zuckerman, 1971), but such changes may have little bearing on the role of central events during orgasm.

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The research of Masters and Johnson (1966) represents a major advance in knowledge of the process of sexual arousal. While their substantial sample (over 700 subjects) is some guarantee of the generality of their findings, the reported data are more descriptive than quantitative. The techniques of direct physiological measurement used were few and relatively unsophisticated. In the description of the female orgasm, for example, these authors comment on the major significance of pelvic vasocongestion and myotonia, yet neither of these responses was quantitatively evaluated. Even where physiological changes were measured directly, as in the case of heart rate, the techinques of data analysis provide no information on important questions such as ranges and standard deviations of response.

Bartlett's study (1956), which concentrated primarily on cardiovascular and respiratory changes from coitus through orgasm, provided interesting data, particularly with regard to the patterns of respiration rate in males and females at orgasm. It is conceivable, however, that in a situation of active copulation heart rate and respiration changes could be a function of somatic musculature involvement rather than a direct index of the process of orgasm. In addition to studying these changes during coitus, Masters and Johnson (1966) have observed psychophysiological correlates of orgasm during masturbation. Not only are these data less subject to somatic movement artifacts, but also, in a large proportion of the samples (especially women), the authors observed that the physiological responses during orgasm produced by masturbation appeared equally (if not more) intense as orgasm occurring during copulation.

Twenty years ago, an attempt was made to record the EEG from six human subjects during the process of masturbation-induced sexual climax (Mosovich and Tallaferro, 1954). Although appropriate quantitative data analysis was not available at that time, visual inspection of the EEG records indicated a generalized slowing of electrical activity with concomitant voltage increases. EEGs from four of the six subjects were characterized by paroxysmal 3/sec waves. Heath (1972) has recorded EEG via deep and surface electrodes in two persons during coitus. He reported finding consistent spike and slow-wave activity in the septal region during orgasm. With respect to the surface electrode recording, however, Heath's data are unfortunately obscured by an abundance of muscle artifact. Moreover, the small number and the severe symptomatology of his subjects (one was intractably epileptic) limit the generalizability of his findings. Also, the same author found spiking activity in the septal area in conjunction with a number of other states or conditions having no direct relationship to orgasm.

Phenomenological reports strongly suggest that sexual climax is associated with a unique state of consciousness. Such a state involves loss of contact with immediate external reality, which psychoanalytic theorists have suggested may be vaguely analogous to a feeling of dying (Keiser, 1952) or "petite mort." Fisher (1973) has speculated that the "blurring" of consciousness might elicit

fears of object loss, and hence be related to orgasmic incapacity in women. The present investigation was initiated in order to obtain a more quantitative analysis of possible central changes associated with orgasm.

METHOD

Subjects

Four males and three females served as subjects. The subjects were a heterogeneous group of individuals, willing to participate in this experiment, but not necessarily representative of the general population.

Subjects ranged in age from 21 to 32, and were all in good physical condition. One female was exclusively left-handed; all other subjects were right-handed. With respect to sexual orientation, one subject (male) was strongly homosexual (Kinsey rating 5). All subjects were sexually active (five to ten orgasms per week), and all subjects masturbated at least twice weekly.

In a preexperimental briefing, the purposes of the experiment and all procedures were fully described; all subjects were paid for their participation.

Choice of EEG Measure: The Significance of Interhemispheric Amplitude Relationships

In recent years, data have accumulated indicating that the two cerebral hemispheres are involved to different extents in cognitive abilities (Dimond, 1972). Thus the left hemisphere (in right-handed subjects) is chiefly occupied with verbal activities while the right hemisphere appears to have a greater involvement in the integration of visual, spatial, musical, and emotional inputs (Harnad, 1973). The differentiation is manifested in the EEG in the form of amplitude asymmetries. Reversals of amplitude asymmetries have been found to occur in normal subjects when switching from verbal to visual tasks (Galin and Ornstein, 1972) or from non-REM to REM sleep (Goldstein *et al.*, 1972) and during drug-induced hallucinatory states (Goldstein *et al.*, 1973). If, as indicated, sexual orgasm is accompanied by an extreme change in cerebral activity, it appeared of interest to ascertain whether quantifiable modifications of hemispheric amplitude relationships would occur.

Recording Methods

Left and right parietal EEGs referenced to common earlobe electrodes were recorded on a Beckman type R polygraph and a TEAC FM tape recorder.

Each channel was buffered to the recorder through a high impedance field effect transistor amplifier (Jusko, 1975).

The EEG signals were analyzed by means of solid-state EEG integrators (Goldstein, 1975), yielding continuous measurements of the amplitudes (voltages) cumulated during successive epochs of equal duration. The data were handled in two ways. First, the successive values of integration for both the R and L leads were plotted against time. Second, for each epoch the R/L ratio of amplitudes was computed; overall mean ratios were then calculated separately for each phase of the experiments. Statistical significance of the changes was ascertained on the basis of the two-tailed *t* test.

For male subjects, penile tumescence was measured by a mercury circumference gauge positioned by the subject at the base of the penis. The calibration and recording technique has been described (Rosen, 1973). For the female subjects, a relative blood flow transducer mounted on a diaphragm ring was positioned intravaginally by the subject (Cohen and Shapiro, 1971). Thus genital changes which have been shown to accompany sexual arousal in both male and female (Zuckerman, 1971) were continuously monitored during the experiments. For both sexes, these data provided verification of the subjective report of arousal and orgasm. The effects of manual stimulation of the penis during masturbation, for example, were clearly apparent on the polygraph tracing which recorded penile tumescence.

Experimental Procedure

In order to maintain complete anonymity and confidentiality of the data, each subject was identified by a code number assigned randomly. To further safeguard against experimental bias, this code assignment and subsequent data analysis were done in a "blind" fashion.

Each subject was then taken into the laboratory, where recording electrodes were connected. The subject was instructed to lie in a supine position with head resting comfortably on a pillow and to maintain the eyes in a constant state throughout the experiment — either open or closed. Only one subject reported being unable to maintain the eyes in such a constant state. The experimenter then withdrew from the sound-and-temperature-controlled recording room for the duration of the experiment.

EEG and other physiological changes were monitored during four separate experimental phases:

1. An initial adaptation period, during which the subject had been instructed ro refrain from movement and to breathe regularly.
2. The onset of the preclimax phase was signaled by presenting a selection of rhythmic music. The subject had been instructed to begin to fantasize sexual imagery without any physical stimulation for a period of approxi-

mately 15 min. Two subjects were shown erotic films and pictures in order to enhance sexual fantasy.

3. Each subject manually masturbated until one or more satisfactory orgasms had been attained. In order to signal orgasm, the subject was instructed to depress a switch at the onset of the climax and to release the switch as soon as the orgasm was completed.
4. A postclimax resting period of 15 min terminated the experiment.

With four periods of approximately 15 min each, the total duration of each session was about 1 hr. After the measurement devices were removed, the subjects were required to fill out a questionnaire, reviewing their subjective response to the experience.

Stimulation Method

All subjects used manual self-stimulation to attain orgasm. A specially shielded DC-operated electric vibrator (Panabrator) was also used by three female subjects and one male subject. The Masters and Johnson studies have demonstrated that self-stimulation is the most reliable and consistent method for attainment of orgasm under laboratory conditions. Moreover, the gross body movements normally associated with coitus make measurement of EEG difficult. Self-stimulation, particularly when vibrator-assisted, can be managed with minimum overt bodily movement, making possible analysis of relatively artifact-free EEG records.

The four male subjects were readily able to produce one orgasm per experimental session, while the three female subjects climaxed between one and three times per session.

RESULTS AND DISCUSSION

All subjects reported in the postsession questionnaire that they had successfully achieved at least one orgasm during the study. One male subject (0813) and one female (0811) indicated that the climax felt somewhat "less intense" than usual. All other subjects reported that the experience felt like a typical sexual response. Individual comments are summarized in Table I.

The amplitude relationships in the right and left parietal channels, as expressed by their ratios, are listed in Table I and illustrated in Figs. 1 and 2. The preclimax measurements were performed on selected periods of the "sexual fantasy" phase of the experiment. Utilized were only those portions of record during which the EEG appeared from visual inspection of the tracings to be most stable and artifact free. The postclimax measurements were taken soon after orgasm. However, in several records, especially for male subjects, orgasm was followed by a short

Table I. Mean R/L Ratios of EEG Amplitudes, Computed on Successive 1-sec Epochs, Before, During, and Following Climax

Subject no.	Sex	Preclimax		Climax		Postclimax		Remarks
		N	Mean R/L ratio ± SD	*N*	Mean R/L ratio ± SD	*N*	Mean R/L ratio ± SD	
0813	M	55	0.97 ± 0.08	25	0.95 ± 0.02	21	0.99 ± 0.07	Orgasm 1 hr before session
0817	M	60	1.04 ± 0.29	24	1.80 ± 0.26[a]	53	1.33 ± 0.38	
0817		50	0.99 ± 0.11	15	1.39 ± 0.22[a]	50	0.99 ± 0.17	
0816	M	49	1.01 ± 0.07	18	1.07 ± 0.11	25	1.06 ± 0.10	Eyes open–orgasm of low intensity, no mental activity
0814	M	68	0.89 ± 0.15	10	1.24 ± 0.28[a]	44	0.98 ± 0.15	Eyes closed–orgasm rated intense
0812	F	47	0.95 ± 0.09	19	2.59 ± 0.82[a]	36	0.96 ± 0.07	Orgasm rated intense
0811	F	79	1.01 ± 0.07	12	0.97 ± 0.77	18	1.01 ± 0.08	Eyes open–orgasm medium intensity (left-handed)
0504	F	45	1.06 ± 0.07	10	2.87 ± 0.79[a]	35	0.95 ± 0.13	
0811				10	0.64 ± 0.69[a]	20		Real orgasm
Left-handed	F	55	0.97 ± 0.07	10	0.95 ± 0.59		0.97 ± 0.09	Faked orgasm
0817	M	55	0.97 ± 0.06	14	2.87 ± 0.55[a]	14	1.05 ± 0.08	Left hand
0817	M	50	0.94 ± 0.08	15	1.63 ± 0.79[a]	20	0.93 ± 0.10	Right hand

[a]Statistically significant difference with preclimax condition (two-tailed *t*-test).

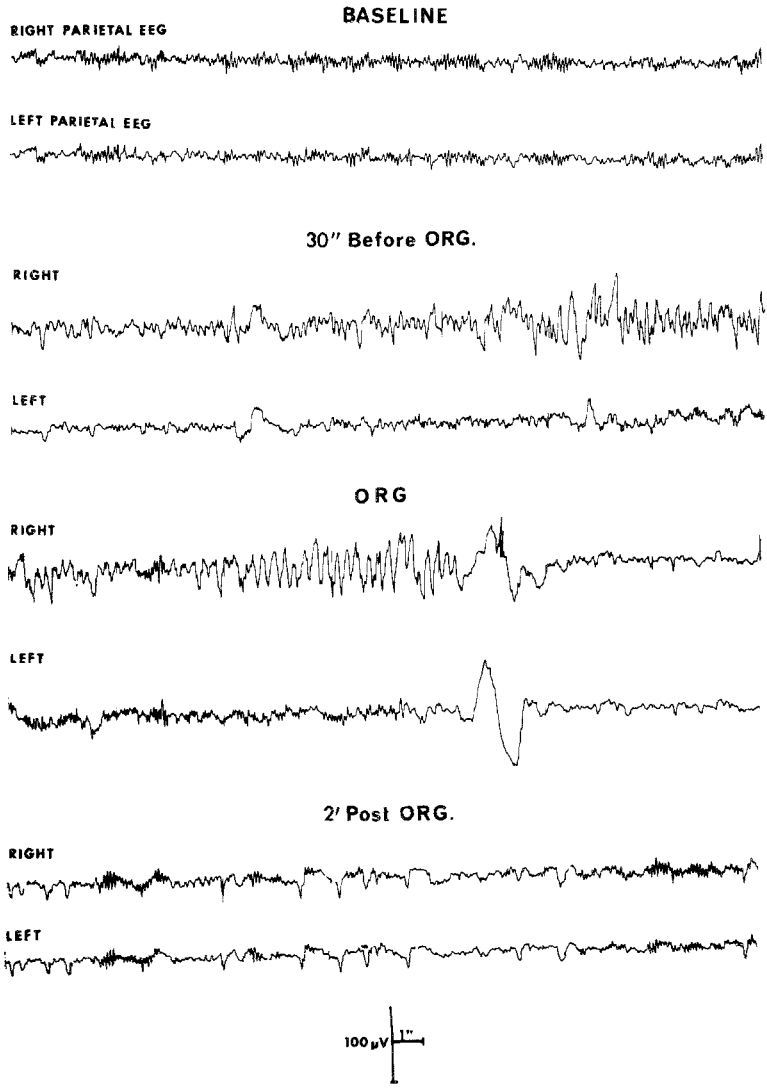

Fig. 1. EEG tracings from the right and left parietal channels in a male subject during baseline, 30 sec before sexual orgasm ("ORG"), during orgasm, and 2 min after.

period of unrest, manifested on the recordings by muscle movements. Therefore, the postclimax samples were taken from the period following when the EEG became stable and scorable. Determination of the beginning and end of the period of orgasm was based on the subject's signal (press on a switch) and genital measurements.

As seen in the table, in eight out of 12 replications, orgasm was accompanied by considerable changes in R/L amplitude ratios, in relation to their pre-

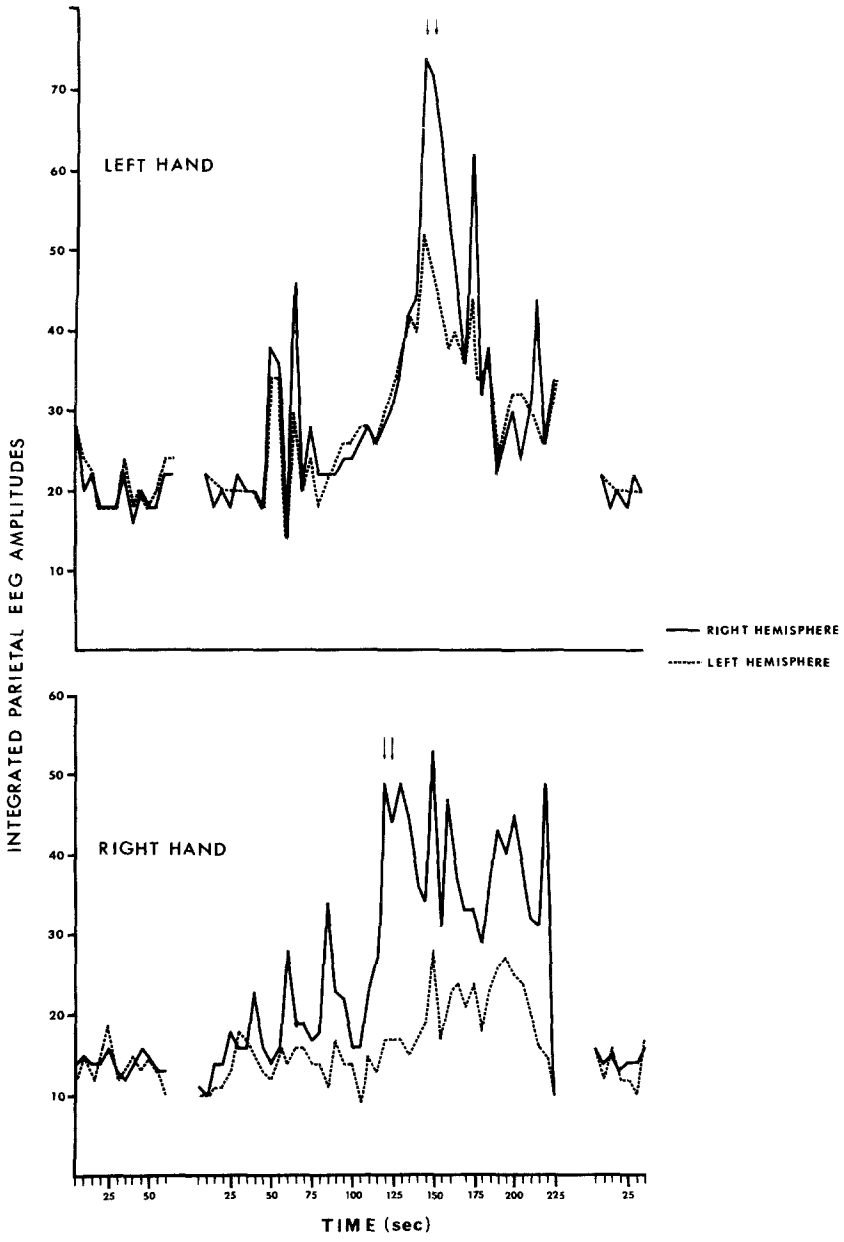

Fig. 2. Time course changes in EEG amplitudes (measured with *m*-line integration) in a male subject using the left hand (upper part) and the right hand (lower part) during masturbation. The arrows indicate periods of orgasm. The chronograms are separated into premasturbation, masturbation, and postmasturbation.

climax values. Except for subject 0811 (left-handed), the change consisted of a large increase in the amplitudes in the right hemisphere, with much smaller increases in the left hemisphere amplitudes. This occurred regardless of the initial R/L ratio, above or below 1.0.

Between-group analysis of statistical significance of the changes observed could not be utilized. Specifically, it was not possible to combine data from different subjects for comparison of preclimax and climax periods of recording. The most obvious reason is that the baseline EEG values are quite variable from subject to subject. In fact, some subjects were found to have baseline R/L ratios below 1.0, and some above 1.0 (Goldstein *et al.*, 1973). The within-subject analysis therefore seemed the most appropriate.

With respect to the number of degrees of freedom used for the t test, it could be argued that the relatively large number of baseline values would distort the information content of the reference state. The difficulty here is that climax is of short duration, and consequently there is an unavoidable difference in the number of measurements (N) obtained before and during climax. Nevertheless, in all cases, the t values were found to be relatively large (i.e., > 2.5). Thus it seems that the number of degrees of freedom used for the baseline mean is of little importance in the determination of the probability level for rejection of the null hypothesis.

Figure 1 illustrates the clearest segments of the preclimax, climax, and postclimax records obtained from subject 0817. Not only is there a visible change in R/L amplitude ratios during orgasm, but in addition the EEG frequencies are obviously different, with a 10-Hz pattern in the left hemisphere vs. 4-Hz activity (with very high amplitude) in the right hemisphere. Apparent frequency changes (noted only by visual inspection in the present study) were manifest in varying degrees in five of the eight experiments in which the R/L amplitude ratios were found to change during orgasm.

Before concluding that the EEG laterality results reported above are directly associated with orgasm, it was felt necessary to test for two possible sources of artifact.

First, in spite of the fact that most nerve fibers from the right hand are represented in the left hemisphere, it was not impossible that through purely muscular transmission the movements of the hand used for masturbation would differentially affect right-side recordings in an unrecognizable way. Second, it was not clear that the pattern of EEG results would differentiate a real sexual climax from a similar pattern of somatic and autonomic tension, without the subjective orgasmic component (i.e., a "faked orgasm"). Two subjects, one male and one female, were recalled to test experimentally these two hypotheses.

1. Subject 0817, a 22-year-old male who seemed readily able to produce orgasm through manual self-stimulation, was instructed for the same experimental procedure described above, with one important exception: he was required to use the *left* hand during the test session. This proved only slightly more

difficult than the use of the right hand, and the subject was able to masturbate to climax. The pattern of EEG activity is illustrated in Fig. 2 and Table I. From the bottom portion of Table I, it is apparent that under both conditions *similar* laterality shifts occurred during orgasm. In both cases, the changes were statistically significant.

2. Subject 0811, a 31-year-old female, who was strongly left-handed, volunteered to produce both a genuine and a "faked" orgasm during the same experimental session. The "faked" orgasm involved the same pattern of overt movement and muscular contractions, but without the subjective experience of sexual climax. No EEG laterality changes were present during the "faked" orgasm (Table I). It should also be pointed out that there was no increase in vaginal blood flow during the pseudo-orgasm, contrasting with the marked increase which took place during the real orgasm.

The absence of discernible changes in the EEG of subjects 0813 and 0816 (Table I) might be due to the fact that the former reported having experienced an orgasm 1 hr prior to the experimental session. The latter (0816) reported being devoid of "mental activity" during the recording period and also judged the orgasm as low intensity. Furthermore, this subject reported keeping his eyes open during the entire period of masturbation, and it may be that laterality changes are less clearly apparent under conditions of α-blocking.

Research findings published previously on right and left hemispheric activity, as related to behavioral tasks or cognitive modes, indicate that enhanced activity is associated with a decrease of the EEG amplitudes in the hemisphere directly involved (Dimond, 1972; Harnad, 1973; Galin and Ornstein, 1972). Thus it could be said from the data obtained in these studies that since the EEG amplitudes are lower in the left hemisphere than in the right hemisphere during sexual orgasm this state corresponds to a greater activity in the left hemisphere. However, such a conclusion might not be warranted in the case of orgasm. When shifts in behavior or cognition occur, they are not necessarily accompanied by changes in the frequency distribution of the EEG (Rosadini, 1975). It is only the amplitude (or power) of the electrical activity within the bands which is modified (e.g., from $R > L$ to $L > R$). During sexual climax, the α-waves are replaced in the right hemisphere by an entirely different wave pattern (in the 4-Hz range), while in the left hemisphere the α-waves are minimally affected. Thus it is a qualitatively different kind of interhemispheric change unrelated to other changes described so far in the scientific literature. This appears to be better interpreted as indicating a dissociation between the right and left EEG, with a change in the right of such a nature and magnitude that it clearly suggests a predominant change in that hemisphere.

Future models of human sexual response will need to incorporate brain phenomena associated with orgasm. This study has demonstrated that the computation of hemispheric amplitude relationships provides a viable methodology for quantitative assessment of orgasmic response. In fact, the amplitude ratio

changes observed were even greater than those recorded under states of sensory deprivation or hallucinogenic drugs (Goldstein *et al.*, 1973).

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