Concerning Emotive Phenomena.—Part III. *The Influence of Drugs upon the Electrical Conductivity of the Palm of the Hand.*

By A. D. Waller, M.D., F.R.S.

(*With a Note on Atropine by* R. Markbreiter.)

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I possess comparatively few data concerning the action of drugs upon "Emotivity" or, to put it more specifically, upon the electrical resistance of the palm of the hand. Except as regards atropine, with which I have made many observations to test the sudo-motor theory of the reaction, I find in my notes only one satisfactory observation upon each of the following drugs: alcohol, chloroform, morphia, which I will transcribe. Obviously, a single observation of any drug can give only a single facet of its action under the particular conditions of experiment. It will, however, be clear that the results have, in each instance, been such as might be anticipated on general principles with one notable exception, viz., atropine.

Experiment 1: *Alcohol.*—A healthy subject, F. G., aged 30, with an initial hand conductance = 17γ (= 60,000 ohms) gave emotive reactions = 3γ to the threat of a burn (match struck) and 2γ to an actual slight burn, immediately before and immediately after the ingestion of 50 c.c. of whisky. The conductance remained unaltered at 17γ.

50 c.c. of whisky or 12½ fl. ʒ is the normal "nightcap" quantity to which the subject is accustomed, and has not produced any marked physiological effect. Experiments with larger amounts of alcohol are required, but are postponed.

Experiment 2: *Chloroform.*—The same subject, F. G., inhaled chloroform at 2 per cent. for one minute, inducing what he estimated subjectively as the first degree of anæsthesia. The conductance of his hand was 20γ (50,000

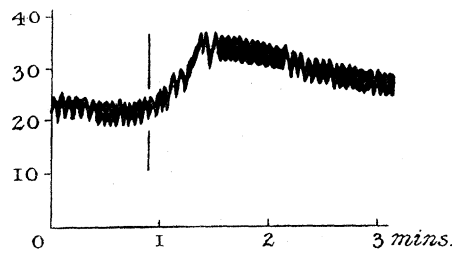

Fig. 1.—Inhalation of chloroform during first half of second minute.

ohms) before and 33γ (30,000 ohms) after the inhalation as is shown by the record (No. 291).

The sudden augmentation of conductance, subsiding gradually to its normal level in 3 to 4 minutes, is due to the excitant action of chloroform. The amount of vapour that was absorbed during the half minute may be estimated as having been approximately 200 c.c. or 1 c.c. liquid or 1·5 grm. This amount according to my previous estimations is physiologically equivalent to 60 grm. of ethyl alcohol which might be contained in say 250 c.c. of whisky. The toxic value of the reagent used has thus been about five times as great in the second experiment as in the first and the results have been in correspondence with this difference.

Experiment 3: *Morphia.*—G. de D., aged 25, received a hypodermic injection of morphia hydrochloride (0·016 grm.) in the course of a prolonged sitting during which she had been subjected to considerable excitement. Her hand conductance had thereby been raised above normal, standing at 160 γ (6,250 ohms) in place of her normal which is 50γ (20,000 ohms) at that time of day —2 to 5 P.M.

The course of the observation was as follows:—

Time.	Conductance.	Resistance.	Remarks.
min.	gemmhos.	ohms.	
0	140	7,100	Observation starts after a considerable excitement.
5	150	6,700	
10	140	7,100	
15	120	8,300	Quieting down.
18	100 to 140	10,000 to 7,100	Morphia injected.
20	140	7,100	
25	130	7,700	
30	140	7,100	
35	140	7,100	
40	80	12,500	Going to sleep.
50	60	16,700	Asleep.
h. m.			
1 0	60	16,700	
1 5	60 to 90	16,700 to 11,100	Awakes with nausea.
1 10	60	16,700	Sleeps again.
1 15	40	25,000	
1 20	50	20,000	
1 25	110	9,100	Wakes with nausea.
1 30	100	9,100	Remains awake with nausea.
1 35	100	9,100	
1 40	40	25,000	Goes to sleep again.
1 45	40	25,000	
1 50	40	25,000	
1 55	80	12,500	Wakes and is sick.
2 0	60	16,700	
2 10	60	16,700	Quiet and gradually feeling better.
2 20	60	16,700	
2 30	50	20,000	

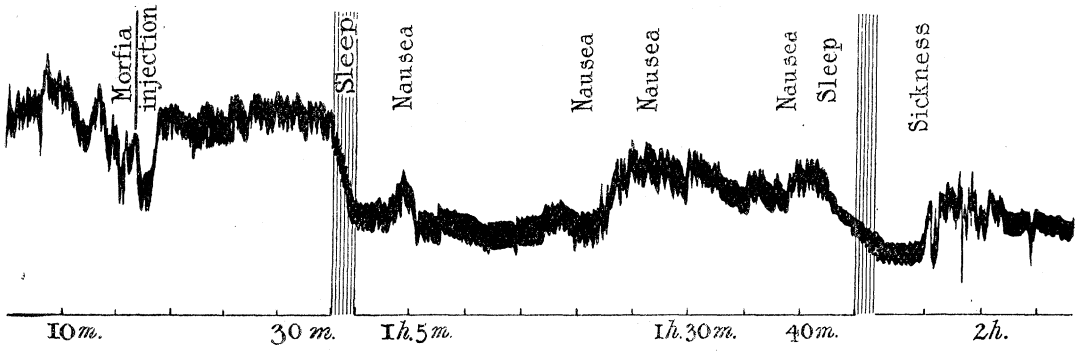

FIG. 2.—Morphia.

Experiment 4: *Atropine.*—As soon as one has realised that the emotive reaction is a true fact, one thinks of the action of sudo-motor nerves, and tests the effect of atropine. I did so at the outset of my experiments, and, being familiar with the sudo-motor effects demonstrable on the cat's foot, as well as with their prompt abolition by atropine, I did so in the expectation of a positive result. I found it quite impossible to persuade myself of the expected result, either by repeated trial and simple observation of the galvanometric spot or by means of photographic records. By simple observation, it is of course possible to arrive at a wrong conclusion; the response varies sufficiently under different conditions for one to think that there has or has not been an abolition or a diminution by atropine. I have therefore taken careful records of the palm treated by local application of belladonna for 48 hours, followed by hypodermic injection of atropine, with the usual general effects, dilatation of pupil, dryness of the mouth, high-pulse frequency, headache and nausea without producing, as far as I could see, the slightest effect upon the emotive response. My observations have not been very numerous—about twenty in all—but the most recent of them have been as thorough as I thought justifiable upon the human subject, and at the conclusion of the last trial I decided not to repeat it. In the face of the statements of other observers, it is useless to assert that atropine has no effect upon the emotive reaction, and I shall content myself with the statement that I have failed to observe it, and that I have recorded instances where it remained, and was apparently of normal magnitude in a subject presenting the usual signs and symptoms of atropine poisoning.

I shall not venture to assert that atropine, in larger dose than I care to employ, like any other powerful toxic agent, such as morphia or chloroform, will not abolish the emotive response. My statement is limited to the specific effect of a small dose.

Atropine Experiment. Plates Nos. 644 to 647. Belladonna plaster on left palm for 48 hours; subcutaneous injection to fore-arm (atropine sulphate, 0·00195 grm.) at end of first half-hour of experiment.

Time.	Conductance.	Remarks.
mins.		
0	50	Start.
5	58 + 1	Sham pin.
7	62 + 2	Real pin.
10	62 + 2	Real burn.
15	68	
20	70 + 3	Pin-prick.
25	70	
27	70 + 3 + 6	Burn.
30	78 + 8	Atropine injection, three tabloids (Wellcome).
35	78 + 2	
40		
45 (No. 746)	80	
52	78 + 2	Pin.
55	74 + 3 + 4	Discomfort.
60	78 + 2	Burn.
63	78 + 2	Spontaneous movement.
65	70 − 8	
70	$\frac{1}{5}$ volt 68 − 4	
75 (No. 747)		
78	74 + 2	Pin.
90	60	
99	60 + 2	Burn.

Pilocarpine, by reason of its sudorific action, might be expected to produce an unmistakable augmentation of conductivity. In two experiments, made *ad hoc*, augmentation of conductivity has been well marked, but the emotive reaction was not appreciably altered.

Experiment 5.—Effect of a Subcutaneous Injection of 0·005 grm. Pilocarpine Hydrochloride.

Time.	Conductivity.	Resistance.
mins.	gemmhos.	ohm.
0	37·5	26,670
10	48	20,830
20	52	19,230
30	62	16,130
40	62	16,130
50	55	18,180
60	51	19,610

The general conductivity of the skin of the hand has been doubled in consequence of the pilocarpine injection. The emotive effects of the four pricks have been +20, +12, +10, and +5. That of the sensation of

nausea was +25. I do not regard the differences as showing any distinct alteration of emotivity under the influence of pilocarpine. The effect on the skin perspiration and upon salivary secretion was evident; 60 c.c. of saliva were secreted during the 70 minutes.

Experiment 6.—Effect of a Subcutaneous Injection of Pilocarpine Hydrochloride 0·006 grm.

Time.	Conductance.	Resistance.	Remarks.
mins.	gemmhos.	ohms.	
0	40	25,000	
10	45	22,000	
12	40 rising to 60	25,000 to 16,700	Pin-prick 1.
18	50 „ 80	20,000 „ 12,500	Injection of pilocarpine.
30	80 „ 92	12,500 „ 10,900	Pin-prick 2.
35	80 „ 105	12,500 „ 9,500	Nausea.
44	70 „ 80	14,300 „ 12,500	Pin-prick 3.
50	60	16,700	
58	45 „ 50	22,000 to 20,000	Pin-prick 4.
72	35 raised to 45	28,500 „ 22,000	Remoisten electrodes.

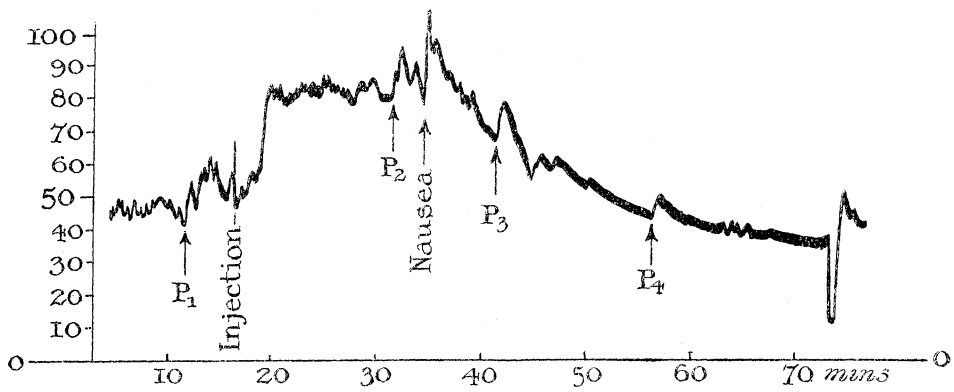

Fig. 3.—Pilocarpine.

The negative result observed after pilocarpine is in agreement with observations I have made in cases of shell-shock where perspiration has been excessive without any corresponding augmentation of conductivity and an emotive reaction greater than normal. The condition is illustrated in the following case:—

Sergeant B....., D.C.M., under the care of Colonel Mott and Captain Golla at the Maudsley Hospital. Shell-shock. Excessive perspiration (electrodes 10 cm.^{2} on back and palm of hand):—

Conductivity.....	37·5 γ	= 27,000 ohms.
Response to threatened pin-prick	+15 „	= 7,600 „
Real pin-prick	+30 „	= 11,900 „
Threat of a burn	+25 „	= 10,700 „
Real burn	+35 „	= 12,900 „

The significance of this case consists in the fact that during a presumably maximal action of sweat glands, the conductivity of the skin has not exhibited great augmentation, whereas great augmentations of conductivity have been caused by emotive excitement without any visible alteration of the sweat discharges. Expressed in terms of resistance, we have for the sweating hand a resistance—27,000 which has suffered diminutions of 7,600–12,900 ohms, *i.e.*, has fallen to 19,400–14,100 ohms during emotive excitement. The obvious conclusion to be drawn is that the emotive changes have not been caused by augmented activity of the sweat glands.

In these experiments we have to bear in mind that the dread of swallowing medicine or actual pain of a hypodermic injection have emotive effects that must be distinguished from the actual influence, if any, of the drug itself. After the first experiments I found it necessary to avoid the complication of several sorts of emotive stimuli, and to take only one sort, viz., a pin-prick as the regular standard test. For self-observation the most convenient standard test of emotivity consists in a voluntary cough, or a sneeze excited by tickling the nostril.

It is interesting to watch the galvanometer while a patient takes a nasty medicine to order at a given moment. A pronounced emotive deflection occurs while the patient is making up his mind, and the observer soon learns to recognise by the galvanometer whether the patient has swallowed his medicine or has failed to make up his mind.

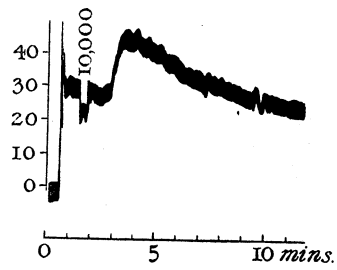

FIG. 4.—Castor oil.

The deflection is single or double according as the imaginary unpleasantness has, or has not, been followed by the real unpleasantness. The sensation of nausea is always attended with a large augmentation of conductance.

There are several facts pointing to the relative independence of electrical from other emotive manifestations, secretory or muscular. Among such facts, the most cogent would be the failure of its abolition by atropine (if admitted), and its presence in undiminished degree during intense secretory

action (*vide supra*, p. 36). Nevertheless, the association between various emotive manifestations is such that it would be hazardous to assert that they are absolutely independent of each other; perhaps the relation between the electrical and the secretory change can be intelligibly conveyed by saying that whereas the electrical is not a consequence of the secretory phenomenon, *i.e.*, in series with it, both phenomena are consequences of metabolic activity, *i.e.*, in parallel with each other. Even this limited degree of association requires the further qualification that our parallel movements may be in opposed directions, *i.e.*, an increased emotive deflection may be accompanied by decreased secretion. Fear dries the mouth, and the following experiment appears to show that emotion can dry the skin, although, as is well known, the usual effect of emotion is increased perspiration. Grief excites tears, but extreme grief may be tearless.

Experiment 7.—Miss G. de D., a Belgian lady, who is familiar with these experiments, and highly skilled in the laboratory methods of carrying them out, prepared apparatus to take a 40-minute photographic record of her own emotive state by means of electrodes on back and palm of one hand and measured the insensible perspiration of the other palm by means of an inverted glass $Ca\,Cl_2$ capsule strapped to the hand and giving by its increase of weight a measure of insensible perspiration. She set herself the task of remaining emotionless during the first 20 minutes, and emotionally unhappy during the next 20 minutes. At the end of these two periods the capsule was weighed showing a smaller increment of weight during the emotional than during the emotionless period, and the developed photogram proved conclusively that these states of mind had been successfully maintained. (The psychological interest of this fact is obvious, it implies considerable power of self-control, of which subjects are more or less capable; the emotional state in G. de D. was secured by voluntary recollection of air-

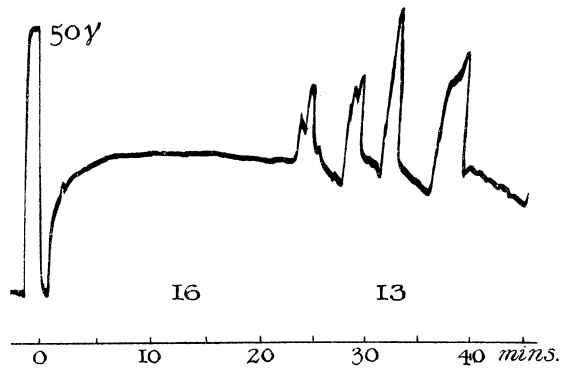

Fig. 5.

raids, and of the "military execution" of a Belgian witnessed at Termonde in 1914.)

The experiment was repeated three times on subsequent days with similar results, viz. :—

Quiet.	Excited.
16 mgrms.	13 mgrms.
10 „	8 „
24 „	15 „

I have taken great pains to satisfy myself about the action of atropine upon the emotive response and have failed to find any evidence that it possesses any action at all upon the response. A negative finding is always unsatisfactory and demands greater bulk of evidence than does a positive finding. But in reality the case is reversed, it is absence of response during atropinisation that is the negative evidence, its presence that is positive evidence. I have repeatedly witnessed emotive response during what I regarded as being adequate if not profound atropinisation. Nevertheless I found it difficult to rest satisfied with the result in presence of the opposite findings of other workers. My statement that such responses do actually occur, and that therefore the emotive effect is not exclusively independent of sweat glands, is based upon observations taken at the outset of the enquiry before its photographic technique had been mastered, and at the last of these earlier observations the result was so clear and the general symptoms of atropinisation so unpleasant that I have not felt it justifiable to repeat the trial for the sake of obtaining a record. In case some future observer may consider it necessary to do so, I shall state what, in my opinion, would constitute satisfactory photographic evidence. A series of emotive responses to a given stimulus, say a pin-prick, then an injection of atropine sufficient to produce general symptoms and abolition of the emotive response.

Local application of atropine by liniment and plaster affords a less convincing test, and can be of value only after the general test has shown atropine abolition. The local test produces no general symptoms, and no local effect. I possess simultaneous records by two galvanometers, one connected with the normal hand the other with the atropinised hand, that exhibit identical large emotive responses in both palms. But as matters stand this is at most a "weak confirmation" of the negative result witnessed in association with general symptoms after subcutaneous injection.

I make no attempt to account for the positive results witnessed by other observers.* Gildemeister, in the same issue of the 'Münchener Wochen-

* Veraguth, *loc. cit.*, p. 185 ; Leva, 'Münchener Medic. Wochenschr.,' 28 Oct., 1913, p. 2388 ; Wells and Forbes, in 'Archives of Psychology,' published by the Columbia University (Verbal communication by Dr. Forbes to A. D. W.).

schrift,' considers that Leva's observations establish with certainty that the p.-g. phenomenon depends upon the sweat glands.

Leva's evidence is particularly strong: he states that in 10 cases the response was abolished by the subcutaneous injection of 1 mgrm. of atropine sulphate,

After 10 to 15 mins. galvanometer deflection, as before,
„ 15 „ 25 „ „ „ distinctly smaller,
„ 30 „ „ „ invisible.

A very graphic description indeed, sufficient to convince any unprejudiced hearer, but nevertheless not in my opinion finally conclusive. Leva is obviously a firm believer in the abolition by atropine, it is possible for a firm believer to watch a more or less steady galvanometer and to *see* responses before atropine and to *not see* responses half an hour later. I had in my laboratory, working at this point for months, a very convinced believer, Mrs. Markbreiter, B.Sc. London, whose report I subjoin. For my own part I do not consider Mrs. M.'s results to be confirmatory of Leva's statements and I regard the latter as inconclusive.

The Effect of Atropine on the Emotive Response.

By Rita Markbreiter, B.Sc. Lond.

Otto Veraguth in 1904 gave the name psycho-galvanic reflex to the following phenomenon, namely, if a current is passed through the body of a subject who is then excited emotionally, either psychically or through one or more of the sense organs, the said current is increased.

Investigators at once asked themselves the question which set of nerves and what cells of the body were concerned in this electrical change. Certain facts pointed to the sweat glands being primarily concerned, and it was thought the emotions aroused caused secretion of the sweat glands to take place, and so gave changed conductivity.

Atropine has the effect of temporarily stopping glandular secretion, and therefore provides an obvious means of proving the above statement.

Veraguth was the first to carry out an atropine experiment: he placed a belladonna plaster on his subject for several days, then took it off, washed the hands with atropine sulphate, and connected the subject with the instrument. He found that the p.-g. reflex was much smaller than in the normal subject, but not entirely extinguished.

Dr. J. Leva in 1913 experimented to find out whether different parts of the body gave different psycho-galvanic results. He found that the field