# ON MEMORY.

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In previous communications I have shown that the excitation processes mediating mind are essentially due to an interaction between Ca salts and colloids; also that behind a response or thought of a particular size there can lie an infinite series of excitation processes differing in the proportions of the two interacting factors. This composition next determines the type, or quality, of thought.

These principles applied to memory showed that a memory trace was a persisting changed state of colloidal aggregation wrought in a nerve-cell through receipt of a stimulus, and that recall of the experience was somehow or other due to subsequent interaction of those changed colloids and Ca salts.

On those principles the fundamental equation expressing a recalled memory would be—

$$H + L = T,$$

where $L$ is a state of colloidal aggregation, or memory trace, $H$ is calcium, or the remembrancer, and $T$ the response of the conscious organ. The factor $L$ also determines feeling tone, and $H$ the intellectual appreciation of the nature of $L$ (1).

The equation shows that, of the same event, an infinite series of memories is possible. "*tot homines quot memoriæ*" in fact, and though it does not show precisely what is perfect memory, it does indicate two classes of imperfect memories, namely those in which $L$ is too great, and those in which $L$ is too small.

For as $L$ increases in size, the feeling tone of the memory increases, and this added tone, considered in ordinary life to bias the individual's judgment of a past event, according to our equation automatically diminishes the capacity to apply to the memory trace enough of the factor $H$ to give good judgment. The limit is reached when the factor $L$ becomes equal to, or even greater than $T$. There is then left no scope at all for $H$, and with this the experience cannot be recalled to mind. It becomes instead what I have termed an expelled memory, but what Freud terms incorrectly a repressed memory (2).

At the other extreme the factor $L$ is so small as to leave the remembrancer, $H$, too little data to work on.

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The equation thus gives two classes of imperfect memories:

1. Those of great emotional experience or content.
2. Those of too small emotional content.

Freud, it should be noted, assumes for the two classes a common mechanism for loss, *viz.*, repression. His mechanism we find wrong.

Now the statement that "Time is the great Healer" represents, I take it, a truth of common experience. I accept its truth, and deduce from it that, in the excitation processes mediating memories, time produces an altered balance. Time heals by reducing the feeling tone of a past experience which, in our equation, implies a reduction in the magnitude of the factor $L$, balanced, of course, by a corresponding increase in the magnitude of $H$. Such an alteration in the balance of its excitation processes provides a more "reasonable" view of that experience, and enables it to be seen in a "different light."

This nature of the healing influence of time, however, is precisely the same as that previously suggested to underlie senescence (1). The healing influence is thus part and parcel of senescence. But a decrease of $L$ balanced by a corresponding increase of $H$ implies retention of cerebral vigour, and though this change of balance carried too far eventually leaves the judge too few data for judging, it yet seems probable that in the last stages the judge himself should also weaken.

This changed composition of excitation processes with the passage of time also alters the capacity of the cells to receive new impressions. An environmental change of a given strength, I find from observation on the heart, produces less change when excitation processes are of the composition here considered senile than when these are juvenile. Accordingly, I deduce that as age advances the production of memory traces will become increasingly difficult. This is, of course, well known. The point to be made about it is its vindication of the reliability of our premises.

Now, so far as I know, there is no evidence that what may be termed the ordinary stimuli of everyday life are increasing in strength. The struggle for existence may possibly be intensified, but the grass is just as green as it used to be, the birds sing just the same songs and so on. If, however, our environment is to produce the same effect on us in old age as in youth, its power would require to increase *pari passu* with our decreased capacity to receive an impression, which, of course, does not happen. What does happen is that, as age advances, less and less of the environment makes impression, until finally the stage is reached of self-centred senility only desirous to live.

If, then, we place an old and a young man in the same environment, the memory traces left by its changes will in each case be greater in the young than the old; also the smaller changes registered in the young will fail to obtain registration in the old. In accord with this, as a man ages, there comes a time when the younger people around him begin to appreciate the fact that father can recall much less of the events of the previous day or week than his children can. Such a failure of memory as is here indicated, however, does not imply a failure of the machinery of recollection, but rather that the machinery obtains nothing to work on. Indeed, if the old gentleman live a sufficiently quiet life, he would presumably get out of his environment nothing to remember. He can only obtain adequate memory traces through outstanding events, such as the death of a near relative, an accident and so on. These outstanding events, however, can be expected on our hypothesis to affect the aged much less deeply than the young, though it can be urged against this that the young can be expected to survive an experience which would kill the aged. The objection, however, would mix up the amount of change produced with the amount of change required to kill. The amount of change produced in the aged may be small, but yet enough to kill, whereas the larger change produced in the young is not lethal.

Digressing at this point from memory to perception, hearing, sight, etc., it is to be pointed out that all these attributes are mediated by the same mechanism. Accordingly an environment which fails to produce enough data for the remembrancer to work on can also be expected to produce too little for the perceivers to work with. Hence mistakes of perception can be expected to accompany this failing memory.

Reverting again to memory, we now observe that, in a system altering with age as nerve-cells have been assumed to alter, ageing implies two changes:

1. The gradual diminution in size of memory traces already present.

2. The reception of memory traces of diminished size from stimuli of constant strength.

Obviously, in that system, the memory traces of the last received ordinary impressions, because of their very smallness, will be the first to have their size reduced below that level which gives the remembrancer adequate data to work on. That is to say, the last received ordinary memories of life will be the first to be lost as age progresses. This loss of ordinary memories can be expected to be regularly retrogressive, until finally the only memory traces of ordinary events possessing adequate size for the remembrancer's activity

will be those of childhood. Next in this scheme, childhood memories are not normally vague because of the small size of their memory traces, but because of their size being so large as to leave too little room for the remembrancer to work adequately. In old age, however, the reduction in size of these memory traces gives a correspondingly greater scope for the remembrancer's activity, and thereby gives judgment and clarity to memories previously dim. Senility may, indeed, be also an efficient psycho-analyst, and bring back to mind forgotten, or expelled, emotional experiences.

We have, however, considered so far only those memory changes which follow on diminution in size of memory traces, such changes being on the whole natural. We conceived the possibility of a general alteration in the composition of cerebral excitation processes taking place in a particular direction, and found that it implied loss at one end of the scale of memory and gain at the other. It is also possible to conceive that changes in the composition of excitation processes should occur opposite to those already described—namely that $L$ should increase and $H$ diminish. In this case an exceptional memory for minor recent events could be anticipated, but a poor judgment of the significance of major events due to too little scope for $H$. Hypermnesia has been described in fevers and after certain drugs, but I have not found mentioned that hypermnesic recollection of minor events was accompanied by faulty judging of past major events. Our equation, however, shows that such faulty judging should be there, so I suggest that, up to the present, the hypermnesia of minor recent events has so astonished observers that faulty judgment of important past events has not been looked for.*

It should be noted, too, that alcohol ought to assist recollection of minor events and give faulty judgment of major ones. At the same time the difficulty would be to find the proper dose, namely the one which would only alter the balance of excitation processes without decreasing their total efficiency. Some of the poets seem to have found what for them was a proper dose.

Any general emotional upset also, by altering the balance of excitation processes, would make important to the sufferer's mind the minor events of life, and leave him incapable of accurately judging the significance of major ones. A general upset of sufficient intensity should indeed leave the individual bereft of memory.

* Coleridge—*Biographia Literaria*, vol. i, p. 117—relates the case of a girl in a "nervous fever" who spoke Latin, Greek and Hebrew. Ecclesiastics considered her "possessed" by a learned devil, but the physicians traced the cause to past experiences. This hypermnesia during a "nervous fever" was evidently also accompanied by faulty judging of more important events.

[Such an association—hypermnesia with faulty judgment—is common enough in maniacal patients.—Eds.]

Finally we observe that if the intensity of cerebral excitation processes undergoes a general decrease memory must suffer. The loss of memory which may follow concussion probably depends on such a general reduction. The amount lost, however, would depend on the individual's previous existence. A general reduction of size might well wipe out ten years from the recollections of the individual who has led a quiet, uneventful existence, and leave abundance for the man who has led a hectic life.

*References.*—(1) Burridge, W., *Journ. Ment. Sci.*, July, 1929, p. 383.—(2) *Idem, ibid*, p. 400.

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