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ON THE ANTI-DEPRESSANT EFFECT OF SUPPRESSING REM SLEEP

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1. *Recapitulation: the function of consciousness is categorization*

In a paper presented to last year's Euro-SPP Meeting in Oxford, Kathleen Taylor and I argued as follows:

We began by defining consciousness as that which is missing from vision in the affected parts of the visual field in lesions of the striate cortex. Thanks to an elegant experiment (Cowey and Stoerig 1995) which Alan Cowey reported in his presentation at last year's ESPP Meeting, we now know that lesions of the striate cortex have the same effect in monkeys as Larry Weiskrantz (1986) has shown that they have in humans. They abolish conscious experience in the affected part of the visual field without destroying the subject's ability to make many kinds of visual discrimination ("blindsight"). This evidence removes a significant element of doubt from the suggestion made in our paper last year that we can use Nick Humphrey's (1974) study of the rhesus monkey, Helen, who had had virtually the whole of her striate cortex surgically removed as evidence of what functions are lost when consciousness has ceased to operate in a particular sensory modality. Interpreted in this way what Humphrey's study shows is that the function of consciousness, defined in the way we propose, is to categorize inputs which the organism identifies as problematic. The evidence on which this conclusion is based is summarized by Humphrey in the following passage:

> "After years of experience she never showed any signs of recognising even those objects most familiar to her, whether the object was a carrot, another monkey, or myself".

2. *The respective functions of consciousness and the sub-conscious system*

In our paper we suggested that this evidence needs to be seen in the light of Donald Broadbent's (1958; 1971) thesis that the part of the brain responsible for categorizing problematic inputs is a "limited capacity

channel" which is protected from overloading by the mechanism of selective attention. From this we conclude that the behaviour of primates and, no doubt, of mammals in general is controlled by two systems:

(a) the *subconscious system* whose function is to separate problematic inputs from the non-problematic, pass on the former for processing by consciousness, while either ignoring the latter or transforming them into outputs in ways that have become so well practised and habitual that no conscious supervision is required (automatic pilot), and

(b) *consciousness* whose function is to categorize the inputs identified as problematic by the sub-conscious system and to select and execute a behavioural strategy appropriate to the problem they present.

3. *The subconscious detection of problematic inputs*

For our present purposes the important component of the subconscious system is the *problematic input detector* (PID - See Figure 1). Its function is to attract the focus of attention to any novel or motivationally significant input. This involuntary and subconscious attraction of to problematic inputs (the subcortical part of Michael Posner's (Posner and Petersen 1990; Posner and Dehaene 1994) "posterior attention system") contrasts and is partially in conflict with (a distraction from) two other forms of voluntarily and consciously controlled attention. One of these, controlled apparently by the superior parietal cortex and thus the cortical part of Posner's posterior attention system, maintains the focus of attention on the problematic input until a satisfactory categorization is achieved. The other is Posner's "anterior attention system (anterior cingulate and basal ganglia)" whose function is to maintain the focus of conscious attention on the task in hand until an appropriate behavioural strategy has been selected (Pashler 1991).

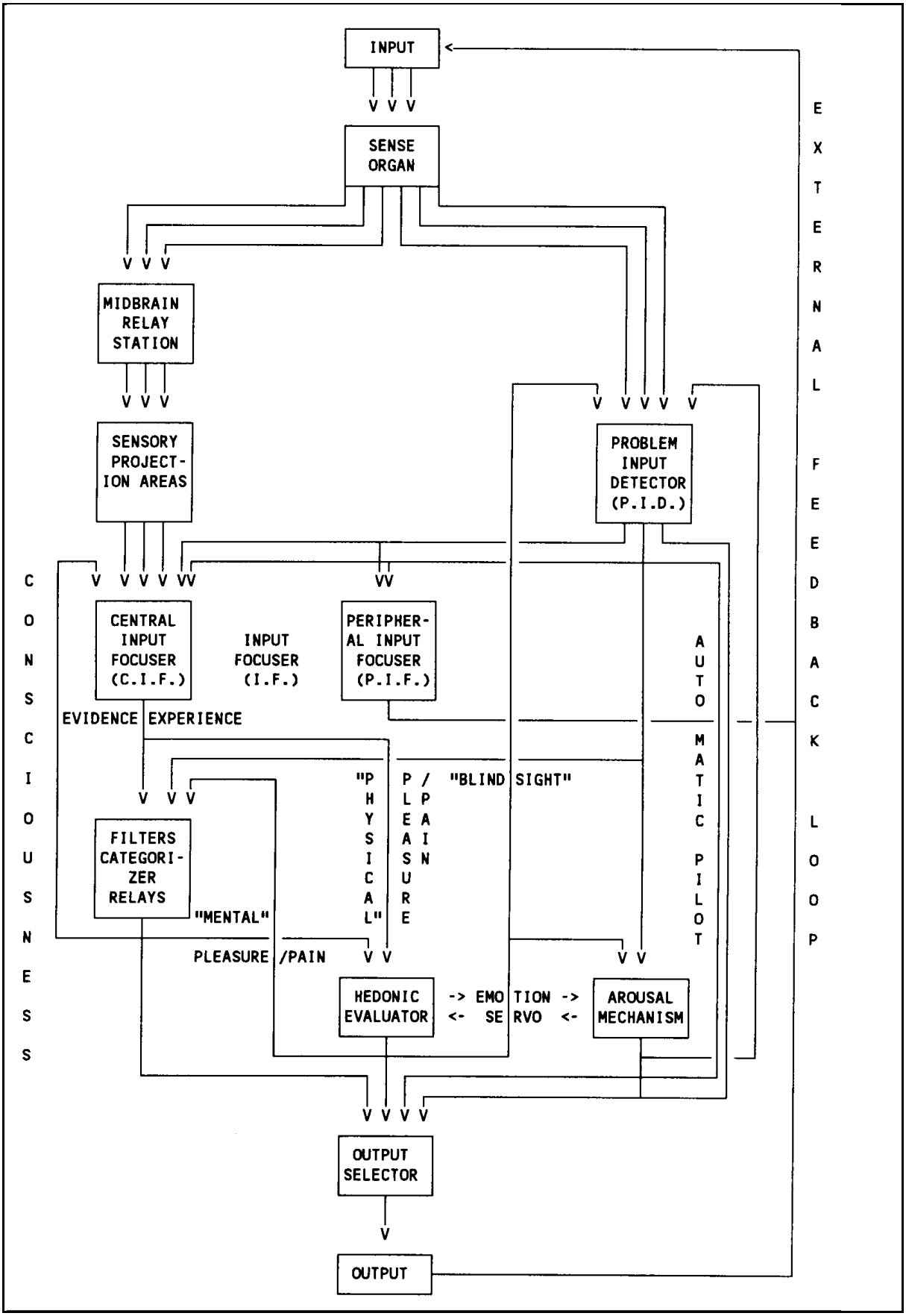

Figure 1. The functional anatomy of consciousness

As we see it, the problematic inputs which are detected and brought into consciousness by the subconscious subcortical part of Posner's posterior attention system (our PID) are of three kinds:

(i) inputs which are unexpected in the sense that they differ significantly either from any input the organism has previously encountered or from the kind of input the organism has come to expect following an input of the kind that preceded it,

(ii) inputs which, though not unexpected, are motivationally significant in the sense that the organism is actively searching or "on the look out" for an input of that kind,

(iii) inputs which, though not unexpected, are motivationally significant in the sense that they are associated with motivationally significant and hence emotionally charged events in the individual's past history.

It is with the mechanism that makes possible the detection of the third of these three types of problematic input that we shall be concerned in this paper.

4. *Conscious experience as central input focusing*

Consciousness as presented on our box diagram (Figure 1) consists of an *input focuser*, controlled by the two partly conflicting subconscious and conscious parts of the posterior attention system, a *categorizer* and a response selection system an important component of which is what we call the *emotion servo*. The input focuser has two components a peripheral component and a central component. The *peripheral input focuser* (PIF) mobilises and initiates movements of sense organs and the parts of the body in which they are located in such a way as to maximise the chances of securing a satisfactory identification of the kind of situation the problematic input represents. The action of *central input focuser* (CIF) is illustrated by the well known "cocktail party effect" and its experimental analogue the so-called "dichotic listening" situation (Broadbent, 1958). It is to be construed, we think, as a restructuring of the figure-ground relations within what Broadbent (1971) calls the "evidence" on which categorization of the input is based which is maintained by the conscious part of the posterior attention system until an acceptable interpretation of what was previously problematic is achieved.

In our paper we proposed to identify this central restructuring of the figure-ground relations within the "evidence", as Broadbent (1971) calls it, on which categorization of the input is based with the *conscious experience* which the introspecting human subject reports and which disappears from the affected parts of the visual field in lesions of the striate cortex. It is the absence of the normal ability to check categorizations against the "evidence" on which they are based when the relevant part of the sensory field is undamaged that makes the often very accurate discriminations of the blindsighted subjects a matter of "pure guesswork".

5. *Mental imagery*

The conception of conscious experience as a central input focuser which modifies the figure-ground relations within the "evidence" on which the categorization of the current problematic input is based leads to a conception of a mental image, whether it occurs in a dream, a day dream, in reminiscence or problem solving, as a product of the central input focuser operating on a weakly structured part of the current input from the sensory projection areas and imposing an internally generated pattern of activation which bears little or no relation to any objective feature of the current input.

6. *Discriminating problematic inputs*

Of the three types of problematic input distinguished above, the cues which allow the sub-conscious system to discriminate the first two are fairly easily understood. Inputs which are novel or which differ from what is expected on the basis of the way inputs have followed one another in the past will stand out as figure against the majority of familiar patterns and expected sequences as ground. Likewise, although the mechanism whereby this is achieved is perhaps less well understood, it is clear that initiating a search for something, if it is to be successful, must involve a temporary disposition of the problematic input detector whereby any input with the desired characteristics will stand out as figure relative to the majority that lack those characteristics as ground.

What is less easy to explain is how attention is caught by inputs which are motivationally significant to organism by virtue of their association in the past with motivationally significant and hence emotionally charged events in the individual's past history.

7. *The function of dream imagery*

It was in this connection that we proposed the hypothesis that the function of the vivid dream imagery that occurs invariably and exclusively during the rapid eye-movement (REM) phase of sleep is to recapitulate the new inputs encountered and the associations formed during the preceding period of waking consciousness under conditions where consciousness is decoupled from the sensory input whose significance it is normally required to interpret. Freed from this constraint, the central input focuser is free to form images and sequences of images which connect up with motivationally significant and hence emotionally charged events in the individual's past history at the expense of those that are motivationally and emotionally neutral. The effect of this, we suggest, is to stamp in the motivationally significant associations at the expense of the motivationally neutral, thereby causing the former to stand out as figure relative to the latter as ground and thus attract focus of conscious attention to them when they recur in subsequent periods when the individual is awake.

8. *The anti-depressant effect of suppressing dream imagery*

What I now want to add to what was proposed last year is the suggestion that this hypothesis can be used to explain a phenomenon which has been known for some thirty years (Oswald 1966, pp.103-4) whereby the effect of taking anti-depressant drugs is to suppress the REM or paradoxical phase of sleep within which vivid dream imagery occurs and to which it appears to be confined. What this explanation explains is not why anti-depressant drugs suppress REM sleep, but why drugs which suppress REM sleep should have an anti-depressant effect.

The suggestion is that in clinical depression the patient is constantly being reminded by the events of daily life of distressing incidents in his or her past life which arouse strong negative emotions, typically, feelings of guilt and remorse. If, as we have suggested, the function of dream imagery is to "stamp in" motivationally charged associations formed during the previous period of waking at the expense of those that [are] emotionally neutral, so that stimuli with emotionally charged associations attract attention while the motivationally and emotionally insignificant are ignored, it should follow that, by abolishing REM and

the dream imagery that goes with it, the stimuli which would otherwise attract attention because of their emotionally charged associations will cease to do so.

9. *The evidence for this hypothesis*

The evidence for this hypothesis may be considered under three headings:

(i) evidence for the reminiscence theory of clinical depression,

(ii) evidence for the predicted correlation between REM-suppression and antidepressant effect, and

(iii) evidence for the predicted effect of REM suppression on pleasant reminiscences.

10. *Evidence for the reminiscence theory of clinical depression*

Although it cannot be the whole story since it does not account for the gloominess of the gloomy thoughts, there is overwhelming evidence, at least in the case of those susceptible to treatment as outpatients, both for the view that clinical depression is maintained by the gloomy thoughts that are a characteristic symptom of this condition and for the view that all effective treatments of it rely in one way or another on breaking the connection between these thoughts and the environmental events which trigger them. This evidence comes from the remarkable success of the so-called 'cognitive therapy' in which an attempt is made to disrupt these repetitive and intrusive thoughts, partly by challenging the irrational and evidentially unsupported assumptions on which they are usually based, and partly by teaching the client to respond either to the environmental cues which trigger the gloomy thoughts or else to the gloomy thoughts themselves when they occur with an antagonistic pleasant thought which will either inhibit the gloomy thought or counteract its depressing effect. It has been shown (Blackburn *et al.* 1981) not only that this treatment regime is just as effective as a course of anti-depressant drugs in the short-term, but also that the effects are much more long-lasting once the course of treatment has been completed.

11. *Evidence for the predicted correlation between REM-suppression and antidepressant effect*

The evidence for the predicted correlation between the amount of REM sleep suppression produced by an anti-depressant drug and its anti-depressant effect is much ambiguous. At one time all known antidepressant drugs had a REM-suppressing effect. This led Vogel *et al.* (1980) to propose that it is REM sleep that produces the depression and that, therefore, it is REM-suppression that is the anti-depressant agent. However, some of the antidepressant drugs more recently discovered, such as nefazodone and moclobemide, have the opposite effect (Sharpley and Cowen, 1995). This is not to say that the antidepressant effect is not produced by preventing the occurrence of the gloomy thoughts that appear to be responsible for maintaining the depression. It may be, as is presumably the case with the well known antidepressant effect of electro-convulsive therapy (ECT), that they produce their effect by disrupting the synaptic connections between the environmental events and the gloomy thoughts they trigger rather than, as is assumed by the REM suppression hypothesis, preventing their formation in the first place. Among those drugs that *do* suppress REM sleep, the suppression is not complete. But there appears to be no very good evidence of a correlation between the amount of REM suppression which a drug produces and its antidepressant effect *while the drug is still being taken and is suppressing REM sleep*. There is evidence, apparently, for a correlation between the amount of REM suppression and the extent to which the antidepressant effect persists after the drug has been withdrawn and REM sleep has returned to normal. But that is a finding which makes no particular sense on the REM suppression hypothesis.

Curiously enough, the strongest piece of evidence for the view that suppressing REM sleep has an antidepressant effect is the observation (Wu and Bunney, 1990) that the most striking antidepressant effect is that produced by total sleep deprivation. But that, of course, fails to point a finger at REM as distinct from the other phases of sleep as the cause of the depression. It is true that Vogel *et al.* (1980) showed that waking patients as soon as they begin to go into REM "produced gradual but sustained alleviation of depression." But the contrast between the gradual alleviation of depression when the onset of REM is prevented contrasts with the much more dramatic effect of total sleep deprivation. When combined with the observation for

which I am indebted to Dr. A. J. Marcel[1] that the gloomy thoughts characteristic of depression are more like the imageless part verbally-formulated thoughts reported by subjects when woken from non-REM sleep, it suggests that both forms of sleep are responsible for the gloomy thoughts that evidently maintain depression. No explanation of this result is readily forthcoming from our hypothesis.

12. *Evidence for the predicted effect of REM suppression on pleasant reminiscences*

Equally indecisive, though perhaps more understandably so, is the evidence for another prediction of the theory, namely that REM suppression should reduce the tendency for environmental events to evoke pleasant thoughts as well as gloomy and unpleasant ones. The fact that no such reduction in the incidence of pleasant thoughts has been reported may be explained in the case of the depressed patient on the hypothesis that while the depression persists all pleasant thoughts are crowded out by the dominant gloomy ones, so that when the depression is lifted it is only the absence of the gloomy thoughts that is noticed by the patient.

Similar considerations can doubtless be invoked to explain lack of any noticeable subjective changes in the case of normal subjects who take REM-suppressing drugs for experimental purposes. In such cases the triggering of emotionally charged thoughts, whether pleasant or unpleasant is presumably not a sufficiently common experience for a reduction in its frequency of occurrence to be noticeable. But if such a reduction does indeed occur, it should not be beyond the wit of man or woman to devise an experimental demonstration of the phenomenon.

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