

CONSCIOUSNESS AS AN INFORMATION PROCESSING SYSTEM

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1. *Conceptual analysis as a source of information about brain function.*

I was prompted to offer this paper as part of the inaugural symposium of Max Velmans' Mind-Body Group by reading a recent book entitled *Neurophilosophy* by Patricia Churchland (1986). One of the principal themes of that book is that the main obstacle to the development of a constructive philosophical approach to the neurosciences is the so-called "ordinary language philosophy" which flourished at Oxford from the mid 1940s to the mid 1960s, in particular the doctrine that what is known as "conceptual analysis", as applied to the concepts of our ordinary psychological language, is the only contribution that the philosopher is in position to make to our understanding of how the mind works.

Now it so happens that in 1954 I published a paper in the *British Journal of Psychology* in which I used the techniques of conceptual analysis which Gilbert Ryle had introduced in his 1949 book *The Concept of Mind* in order to demonstrate the inadequacy of Ryle's own account of what he called 'heed concepts.' Ryle's theory of heed concepts is an attempt to account for the concepts of Attention and Consciousness, as they occur in ordinary language, in terms of the notion that to pay attention is to be disposed to perform effectively. In this paper I showed that the facts about the way we use these concepts in ordinary language, as revealed by conceptual analysis, supports the traditional view that, in so far as it does not consist of publicly observable movements of the head, eyes, nostrils, fingers, etc, paying attention is an internal non-muscular activity whereby the individual exercises a measure of control over the relative vividness or salience of the different parts of the total pattern of stimulation currently impinging on the receptor organs.

'The concept of heed' ends with the following sentence:

It is my belief ... that the logical objections to the statement 'consciousness is a process in the brain' are no greater than the logical objections which might be raised to the statement 'lightning is a motion of electric charges'.

I defended this suggestion in a much better known follow-up paper entitled 'Is consciousness a brain process?' which appeared in the *British Journal of Psychology* in 1956 in which

The thesis that consciousness is a process in the brain is put forward as a reasonable scientific hypothesis not to be dismissed on logical grounds alone.

The implication of these two papers, when taken together, is that the conceptual analysis of ordinary language, far from being an obstacle in the way of our understanding of how the brain works, can actually be used to throw light on the nature of some of the processes occurring within it.

Now to say that a conceptual analysis of ordinary language concepts can be used to throw light on the nature of some of the processes in the brain which control our behaviour is not to say, as Churchland seems to think, that *all* the features of our ordinary psychological language have their counterparts in the brain. Still less does it imply that there is nothing to be added to the story from empirical research in the behavioural and brain sciences. Clearly there are many features of our ordinary psychological language which serve functions which are entirely irrelevant from the standpoint of a scientific understanding of how the brain works. Equally there are others which reflect an intimate contact between human language on the one hand and human behaviour, viewed both from without and from within, on the other, stretching back over the millennia that separate us from the birth of language itself. But, as I see the matter, it is only through the kind of understanding of how our ordinary psychological language works, an understanding that only conceptual analysis can give us, that we can hope to separate the scientifically significant wheat from the scientifically insignificant chaff.

2. Consciousness in relation to Broadbent's (1958) Information Flow Diagram.

In the time available, I cannot hope to give an exposition of how the conclusions of a conceptual analysis of ordinary language are reached. The most I can hope to do is to present the conclusions, as I see them, in diagrammatic form as shown on Table 1. This table presents a taxonomy of psychological verbs and other psychological predicates in the form of a flow diagram in which "information" flows down the page from input to output. The key to ordering the taxonomy in this way is the observation (Place 1973) that an instantaneous mental event, such as noticing something or deciding to do something, is the "interface" between an antecedent mental process (paying attention in the case of noticing, deliberating in the case of deciding) and a subsequent and consequent dispositional state (knowing that it is or was there in the case of noticing something, intending to do it in the case of deciding to do something).

Arranging the taxonomy of psychological predicates in this way reveals a remarkable parallel between the pattern which emerges from the conceptual analysis and the "tentative information flow diagram for the organism" which Donald Broadbent first published in his 1958 book *Perception and Communication* (Figure 7, p. 299 - see Table 2).

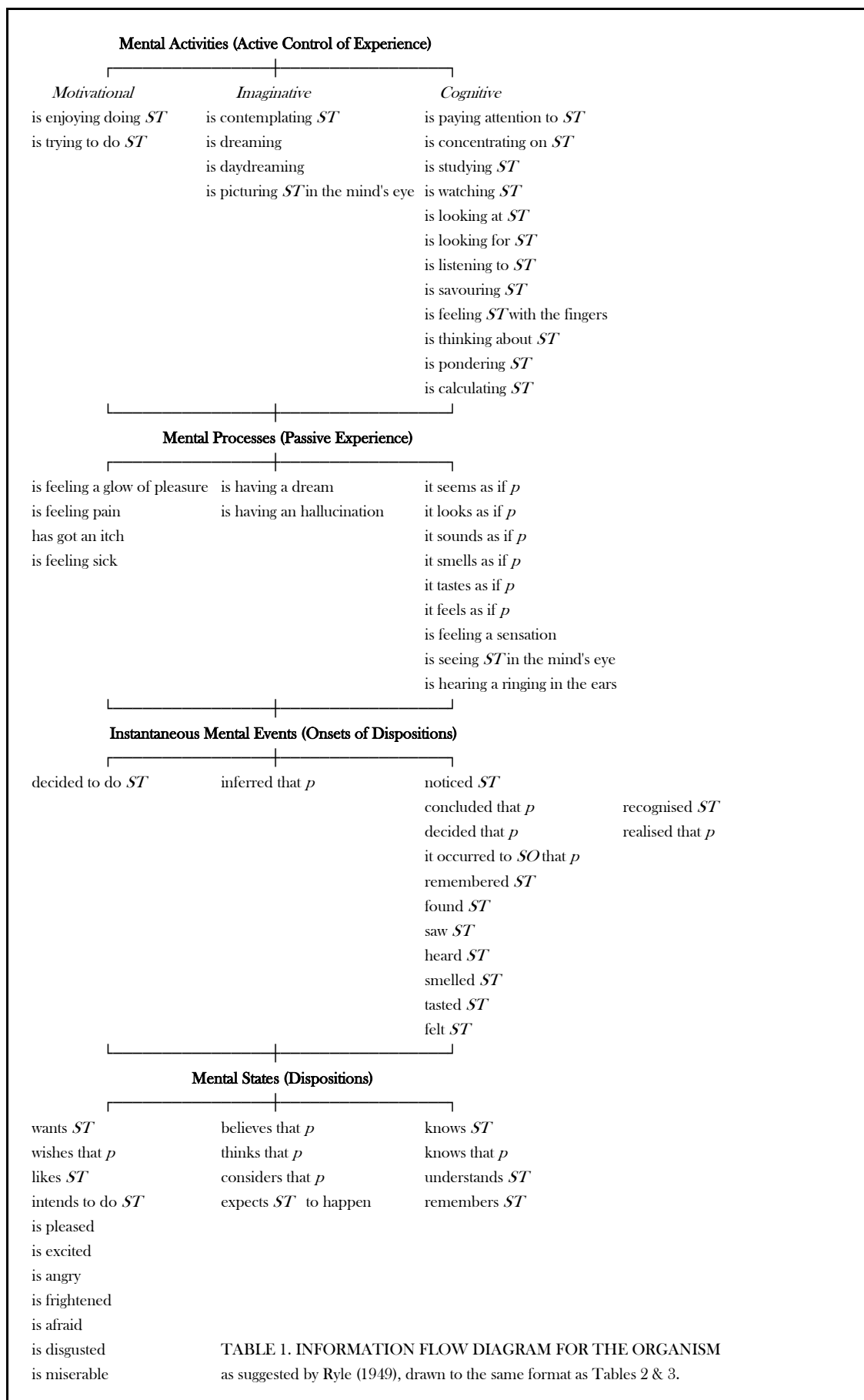


TABLE 1. INFORMATION FLOW DIAGRAM FOR THE ORGANISM as suggested by Ryle (1949), drawn to the same format as Tables 2 & 3.

I first drew attention to this parallel in a paper entitled 'Burt on brain and consciousness' (Place 1969) which was my response to the second of two papers entitled 'Brain and consciousness' (Burt 1968; 1969), in which the late Sir Cyril Burt had set out to defend mind-brain dualism in the face of the then rising tide of materialist views in both philosophy and psychology. In my paper, I proposed an identification of Consciousness with the line on Broadbent's information flow diagram which connects the **SELECTIVE FILTER** to the **LIMITED CAPACITY CHANNEL**. This identification appears to coincide rather closely with Posner and Warren's (1972) definition of a "conscious process" as "one that makes use of the brain's limited capacity central processor" (Velmans 1987). Posner and Warren's formulation, however, is open to two different interpretations. On one interpretation consciousness is construed in the way I proposed in 1969 as the pre-processed input into the limited capacity channel from the selective filter. On the other interpretation it is construed as (or as including) the activity of the limited capacity processor itself. On the first of these interpretations, consciousness is construed as Titchener, for example, construed it, namely as equivalent to Wundt's "immediate," "raw," i.e., uninterpreted, unconceptualised experience. On the second interpretation, it becomes something more like Kant's notion of experience in his well known statement to the effect that "experience without concepts is blind". My own view on maturer reflection is that there is a place for three distinct notions:

- (a) the Wundt/Titchener notion of *raw uninterpreted experience* corresponding to the input from the **SELECTIVE FILTER** into the **LIMITED CAPACITY CHANNEL** on Broadbent's diagram;
- (b) the Kantian notion of *interpreted/conceptualised experience* corresponding to the output of the **LIMITED CAPACITY CHANNEL**; and
- (c) *consciousness*, understood as the total system of processes of which these elements are part.

3. *Broadbent's (1971) revised theory and its diagrammatic representation.*

In 1971, Broadbent published his book *Decision and Stress* in which he reviewed, criticised and emended the theory presented in the 1958 book in the light of subsequent experimental work. Although the changes proposed in the 1971 book are substantial, Broadbent omitted to provide an updated version of his tentative information flow diagram incorporating these changes. He simply reproduces the 1958 diagram without modification.

Since the changes and additions which Broadbent was proposing in the text appeared to me to strengthen the parallel between his theoretical scheme and the pattern which emerges from the conceptual analysis of our ordinary psychological language, I felt this to be a grave omission. Consequently, over the following ten years or so, I produced a number of modified versions of the 1958 diagram which incorporated

both Broadbent's 1971 modifications and certain other modifications and additions which are suggested by the conceptual analysis. Having left the matter in abeyance for the past six or seven years, I re-read the relevant passages of *Decision and Stress* for the purpose of the present paper and produced the latest version which is reproduced here as Table 3.

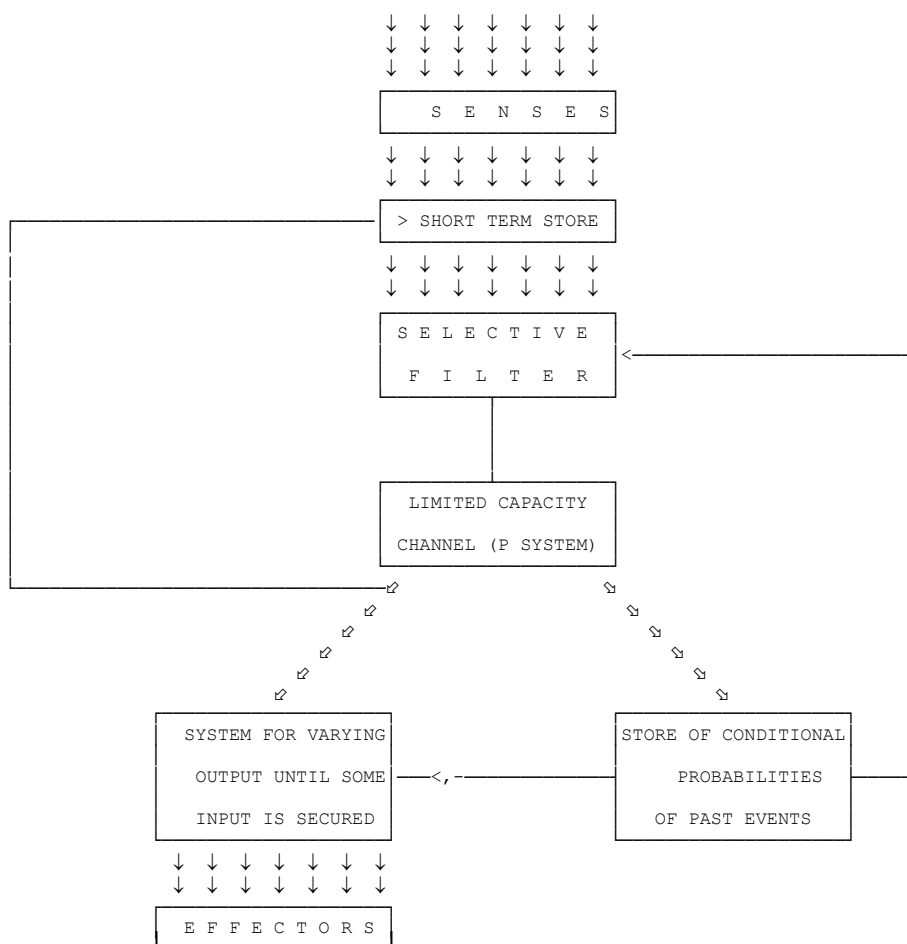


TABLE 2. INFORMATION FLOW DIAGRAM FOR THE ORGANISM, as proposed by Broadbent (1958), re-drawn to the same format as Table 3. below.

The present version differs from the original diagram in incorporating modifications of five different kinds:

- (a) it includes the modifications and additions introduced by Broadbent in *Decision and Stress*;
- (b) it includes some additional features which, although not proposed by Broadbent himself, are designed to accommodate points which he makes in his revised theoretical analysis;
- (c) it includes some modifications, notably the elimination of the Long Term Memory Store, which are not part of Broadbent's scheme, but which are suggested by more recent theoretical work on nerve networks in the light of the development of the parallel distributed processor;

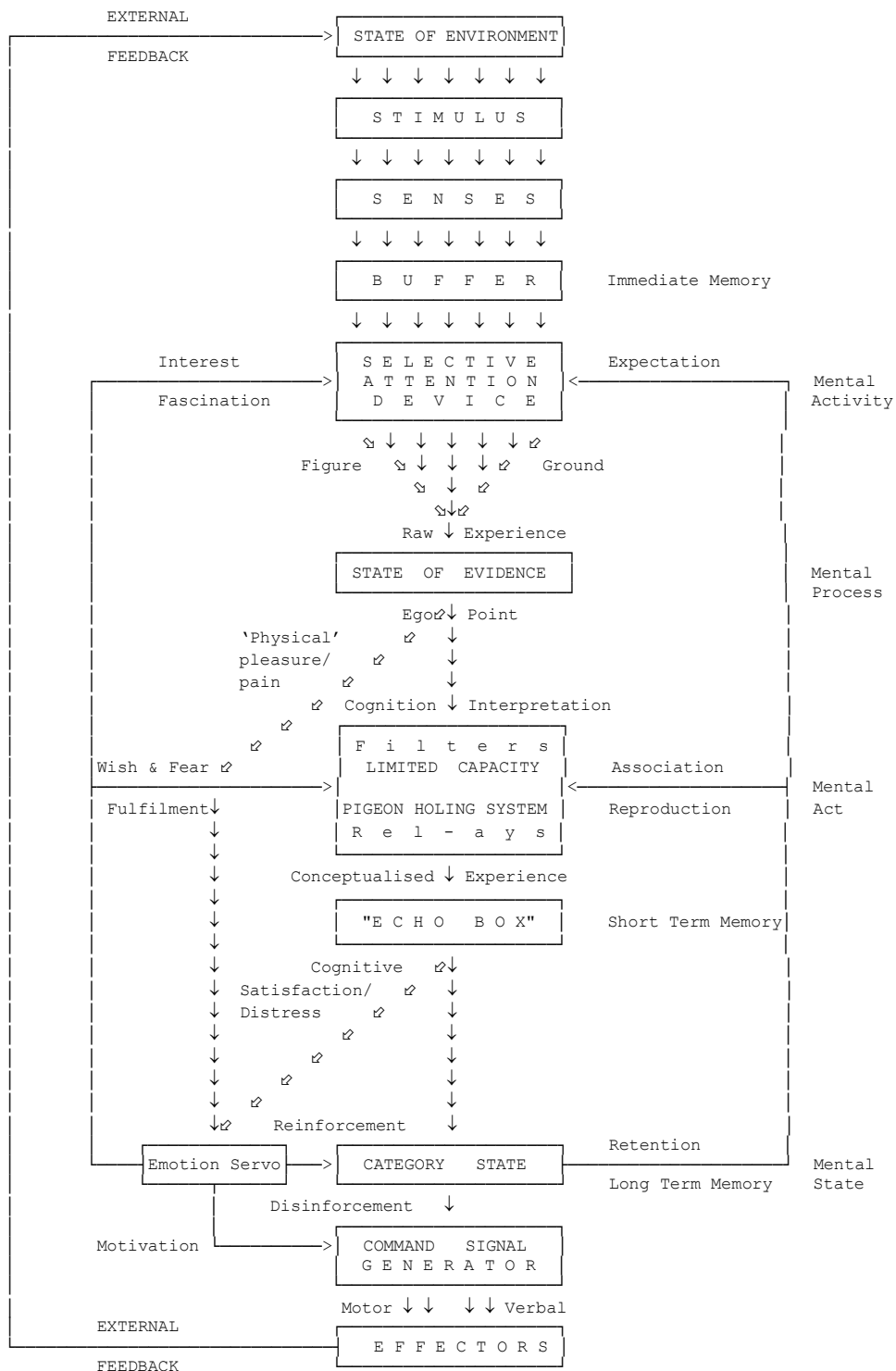


TABLE 3. INFORMATION FLOW DIAGRAM FOR THE ORGANISM, based on Broadbent (1958) with modifications from Broadbent (1971) + additions by UTP - Broadbent's terminology U/C.

- (d) it includes some additional features, such as the two routes of access into a new unit which I have called the "Emotion Servo," which are based solely on considerations derived from the conceptual analysis of our ordinary psychological language;
- (e) I have also indicated (in lower case glosses) my suggestions as to the way in which some of the more important concepts of common sense psychology map onto this revised Information Flow Diagram.

The remainder of the paper will be devoted to a detailed discussion of these additions and subtractions, focusing particularly on the seven modifications to his view since the 1958 book which Broadbent describes in Chapter I of *Decision and Stress* (1971, pp. 12-16) and on the way these modifications are represented in the revised diagram.

4. *Broadbent's first modification.*

The process whereby information is transmitted through the nervous system is now seen as proceeding in four stages:

- (a) in the first stage, the "State of the Environment" projects a "Stimulus" onto the organisms receptor organs; this is represented on the revised Diagram by the gloss "STATE OF ENVIRONMENT" at the top of the diagram above the set of arrows pointing downward to the box marked "SENSES" and the gloss "STIMULUS" below it in the interstices of the arrows;
- (b) in the second stage, information is transmitted *via* the Senses, the Short Term Store or Buffer and the Selective Filter/Attention Device the output from which constitutes what Broadbent calls the "State of Evidence;" this is represented on the revised Diagram by a new box, bearing the title "STATE OF EVIDENCE," between the output of the Selective Attention Device and the input into the Limited Capacity Pigeon-holing System;
- (c) in the third stage, the State of Evidence is classified or "pigeon-holed", to use Broadbent's term, in the Limited Capacity Channel whose output, after passing through an intermediate memory store known as the "Echo-Box" (See Modification (4) below) constitutes a "Category State"¹ whereby the current State of Environment is interpreted as an event or state of affairs of a familiar kind for dealing with which the system has a number of ready-made behavioural strategies to call upon; The Category State is represented on the revised Diagram by a new box, bearing the title "CATEGORY STATE," between the output of the Echo Box and the input into the Command Signal Generator;

¹ It should be noted that the Category State is a state of a rather different kind from the State of Environment and the State of Evidence. Both the State of Environment and the State of Evidence are notional slices through an ongoing process of continual kaleidoscopic change at the point where those processes trigger the selection of a particular pigeon-hole/category state. The resulting category state, on the other hand, is a disposition which persists for a longer or shorter period of time after its selection. In this connection we need to distinguish two types of dispositional state to which Ryle (1949 p. 100) draws attention when he contrasts "short-term tendencies" with long-term dispositions and capacities. A long-term disposition is something like a habit or a belief which manifests itself intermittently over a long period of time. Once formed, these long-term dispositions and capacities often persist for the rest of the individual's natural life. A "short-term tendency" is something like a thought, a state of readiness or expectation or an emotional state which usually persists for a matter of seconds, minutes or, possibly, for a few hours. Using the model of the electromagnetic relay described below, one could say that a long-term disposition is what is brought about by the way the relay contacts are wired up; while the short term tendency is what comes into being when the relay is energized. In Broadbent's terms, the long-term disposition is the category state; the short-term tendency is the temporary selection of a particular pigeon-hole.

- (d) in the fourth and final stage, an effector output is selected on the basis of an evaluation of the Category State in the light of the organism's current motivational propensities in a unit which, following Sperling (1967) and as described and endorsed by Broadbent (1971, pp.368-9), I have called the "Command Signal Generator." This is represented on the revised Diagram by another new box located between the output of the Category State and the input to the Effectors which bears the title "COMMAND SIGNAL GENERATOR."

Errors (i.e., mismatches between the actual State of Environment and the final Effector output) can arise a consequence of discrepancies and loss of information at any of these four stages.

5. Broadbent's second modification.

This concerns the "rules" or principles governing the different elements of the information processing system. It falls into two parts. In the first of these parts, previous assumptions about the "rules" or principles governing the transmission of information between the Stimulus and the State of Evidence are modified away from the notion of the Selective Attention Device as a filter which excludes all inputs but one from access to the Limited Capacity Channel and towards the notion that its function is to bring one part of the total input at any one moment into focus with the remainder of the current input performing the subordinate but, nonetheless essential function of providing a contrasting background to the central figure. This is the point which I take Broadbent to be making in the following passage:

If ... we are listening to speech from a loudspeaker placed on our right-hand side, and ignoring speech coming from the left, sounds arriving from the right will play a large role in deciding which words we hear. The difference from the older view is that sounds from the left side are not shut out from all possibility of affecting the limited capacity system; they merely receive less weight, because fewer states of evidence can result from any particular stimulus on the left ear. (Broadbent 1971, p. 13)

In interpreting this somewhat cryptic statement for the purposes of constructing my modified information flow diagram, I have taken Broadbent to mean that the function of the Selective Attention Device is not, as it was originally taken to be, to prevent all but a single element of the total input from the receptors at any given moment from gaining access to the Limited Capacity Channel. It is rather a matter, to use a concept derived from Gestalt psychology, of establishing a Figure-Ground relationship within the total input such that the feature which is in the current focus of attention becomes figure with respect to the rest of the input as background.

The implication of this is that the whole of the current input has a role in the selection the State of Evidence which is produced by the action of the Selective Attention Device on the information passed on by the Senses from the current Stimulus. The principal function of that part of the total Stimulus which is

assigned within the State of Evidence to the Ground rather than the Figure is to provide a context or setting is to facilitate the effective pigeon-holing of that part of the State of Evidence which corresponds to the figure. But it also appears necessary to assume that there is a constant monitoring of those aspects of the input which are peripheral to the focus of attention for anything unusual or unexpected. Otherwise it is difficult to account for the way in which the focus of attention is immediately attracted by anything unusual which occurs in a part of the sensorium which has been temporarily outside the focus. In order to represent this state of affairs diagrammatically I have replaced the single line which in the 1958 diagram connects the Selective Filter to the Limited Capacity Channel with a fan of outputs from the Selective Attention Device converging on the State of Evidence and thence *via* what I call the "Ego point", of which more later, into the Limited Capacity Pigeon-holing System.

One of the most important advantages of construing the selective attention mechanism as a focusing rather than a filtering device is that, when combined with the notion of a feed-back control of the mechanism from the output of the limited capacity channel, it allows us to account for the phenomenon of mental imagery. The suggestion is that, if attention is focused on a part of the total sensory input which is "weakly structured", in the sense that the stimulus state permits a large number of different figure ground relations to be formed from it as in the classic case of the Rorschach Ink Blot, the character of the resulting state of evidence will be determined by the nature of the feed-back control coming from the output of the limited capacity channel rather than by the stimulus state as in sense perception.

Quite apart from the sheer elegance of this interpretation of the phenomenon of mental imagery, there are at least two lines of evidence, both of which relate to the phenomenon of dreaming, which support the suggestion that imagery in general and dream imagery in particular is a by-product of the mechanism of selective attention. The first of these is the phenomenon of rapid eye movement sleep which combines the following features:

- (i) rapid eye movements;
- (ii) a massive inhibition of the skeletal musculature;
- (iii) a high incidence of reported dream imagery with little or no imagery reported outside this phase of sleep;
- (iv) undifferentiated internally generated firing in the visual input channel.

I am not suggesting that the first of these features, the rapid eye movements, should be interpreted in terms of the notion that sleepers are following the movements of objects in their dreams with their eyes. What I am pointing to is the contrast between this eye-movement activity and the simultaneous massive inhibition of the skeletal musculature. This shows that the eye-movements belong to an entirely different

part of the system from the skeletal musculature; they are simply the muscular, and hence publicly observable, part of the mechanism of visual attention. The function of the massive inhibition of the skeletal musculature is evidently to prevent the extensive and maladaptive somnambulism which would otherwise occur in response to dream imagery. At the same time, the undifferentiated internally generated firing in the visual input channel presumably provides the inbuilt Rorschach ink blots from which the visual imagery that is so characteristic of dreaming is constructed.

The second piece of evidence which supports the view that mental imagery is a by-product of the selective attention mechanism is the phenomenon of the nightmare or anxiety dream. This is discussed in more detail on pp. 20-21 below in connection with Broadbent's discussion of the effect of motivation on perception in his third modification.

The second part of Broadbent's second modification involves a change in his conception of the "rules" or principles governing the transmission of information between the State of Evidence and the Category State *via* the Limited Capacity Channel. This is now elaborated in terms of the notion of the Limited Capacity Channel as a classifying or "pigeon-holing" device. This process is discussed in more detail in connection with the fifth modification below.

6. *Broadbent's third and seventh modifications.*

Broadbent's third modification concerns the effect of motivation on perception. The effect of motivation on perception is construed as acting on the Limited Capacity Pigeon-holing System, thus influencing the selection of the Category State, and not, as previously assumed, acting on the Selective Attention Device and influencing the selection of the State of Evidence. His seventh modification concerns the effect of stress (or arousal) in changing the characteristics of the information-processing system. It is proposed that stress/arousal be construed "not simply as a source of distracting stimuli, but rather as affecting general properties of the entire system" (Broadbent 1971, p.16).

I shall discuss these two modifications together because, in my view, motivation and emotion are simply different aspects of the same phenomenon, and both are accommodated on the revised Diagram by the introduction of a new Box bearing the title "Emotion Servo." The two lines of evidence which lead me to this conclusion are conceptual in nature. The first is an observation to which I drew attention in a paper (Place 1982) in which I suggested some modifications and improvements in the account of language presented by B.F. Skinner in his book *Verbal Behavior* (Skinner 1957). I pointed out

that to say of someone that they want something to come about entails that they will be (a) *pleased*, if they think that what they wanted has come about; (b) *excited*, if they think it is about to come

about; (c) *worried* or *anxious*, if they think it may not come about; (d) either *angry* or *depressed*, if they think that it has not, will not or will not now come about; and that to say of someone that they don't want something to come about entails that they will be (a) *angry* or *depressed*, if they think that what they didn't want to happen has in fact come about; (b) *afraid*, if they think it is about to come about; (c) *hopeful*, if they think it may not come about, and (d) *relieved*, if they think it has not or will not now come about. Evidence that these predictions are entailed by the statements that someone wants or does not want something is provided by our linguistic intuitions, which tell us that it is self-contradictory, for example, to assert that someone wants something, but would not be pleased if he thought that what he wanted had come about, or to assert that someone does not want something to happen, but would not be angry or depressed if he knew that what he didn't want to happen had come about. (Place 1982 pp. 125-6)

What this evidence suggests is that the notions of *wanting* and *not wanting* can be analysed as or reduced to the disposition to display opposite emotional reactions depending on what is interpreted as being about to take place, or as having already taken place; and that, consequently, the same brain mechanism can be invoked to explain both the phenomena of emotion and the phenomena of motivation.

The second piece of conceptual evidence which is relevant to the postulation of what I am calling the "Emotion Servo" comes from C. S. Myers' (1923) critique of Wundt's (1896) *tridimensional theory of feeling*. Wundt, it will be remembered, proposed that each discriminably different "feeling," in the affective sense of that word, can be assigned a unique position in a three dimensional "space" defined by the dimensions of

- (a) *pleasantness-unpleasantness* (German - *Lust-Unlust*),
- (b) *excitement-depression*² (German - *excitirende-deprimierende*), and
- (c) *strain-relaxation* (German - *spannende-lösende*).

Myers' point is that Wundt's *excitement-depression* and *strain-relaxation* dimensions are not conceptually independent of the *pleasantness-unpleasantness* dimension, since "relaxation" and "excitement" have pleasant connotations, while "strain" and "depression" have unpleasant connotations. He, therefore, proposed an alternative two-dimensional theory, retaining the *pleasantness-unpleasantness* dimension, but substituting a single *high activity-low activity* or, as we would now say³, *high arousal-low arousal* dimension for Wundt's *excitement-depression* and *strain-relaxation*. On this view, *excitement* and *strain* are the pleasant and unpleasant forms of high arousal respectively, while *relaxation* and *depression* are the pleasant and unpleasant forms of low arousal.

In line with this theory of Myers, we can propose that the Emotion Servo has two effects:

- (a) the effect of increasing or decreasing the level of arousal (Myers' *high activity-low activity* dimension),
- and

² Here following Judd's (Wundt 1897) translation of Wundt's "*deprimierende*" as "depressing" rather than "calm," as given by Boring (1950 p.330). Judd's translation makes Myers' (1923) point very much clearer.

³ It is intriguing in this connection to find Wundt (1896) using *erregenden-beruhigenden* (translated by Judd in Wundt 1897) as "*arousing* and *subduing*" (Judd's italics) as his characterization of what is here identified as the excitement-depression dimension.

- (b) the effect of strengthening (reinforcing) and weakening (disinforcing) the response tendencies of the organism in accordance with the Law of Effect (Wundt's *pleasant-unpleasant* dimension).

Not only have conceptual considerations guided the formation of the concept of an Emotion Servo, they have also guided the way it is shown as wired into the system. Thus, two routes of access are shown from the output of the State of Evidence to the input of the Emotion Servo:

- (a) one by way of the Limited Capacity Pigeon-holing System, representing those emotional reactions which depend on the way an input is understood, construed or interpreted, and
- (b) another proceeding directly from the output of the State of Evidence and by-passing the Limited Capacity Pigeon-holing System which represents the phenomenon of "physical pleasure" and "physical distress" in which the emotional reaction is a direct response to the stimulus and does not depend on the way the input is interpreted.

This piece of wiring has the curious consequence of generating a kind of node in the diagram at the point where these two routes bifurcate which for reasons which, I trust, will be obvious, I have called the Ego Point⁴.

The Emotion Servo is shown with two ongoing outputs leading

- (a) to the Category State, representing the effects of Reinforcing (Skinner 1938) and Disinforcing (Harzem and Miles 1978) Consequences in strengthening and weakening respectively the organism's propensity to emit responses appropriate to an encounter with the kind of object, event or state of affairs for which it is the function of the Category State to prepare the organism, and
- (b) to the Command Signal Generator representing the effect of motivation in conjunction with the output of the Category State in selecting an Effector output which is appropriate both to the prevailing situation and to the current motivational state of the organism.

The revised Diagram also shows a feed-back loop from the Emotion Servo which leads both

- (a) to the Limited Capacity Pigeon-holing System, representing the effect of Fear and Wish-fulfilment on the way inputs are interpreted, and more controversially
- (b) to the Selective Attention Device, representing a similar effect on the way Figure-Ground relations are organized within the State of Evidence.

⁴ It is well known that this intuition that we have of consciousness focusing on a single point was the principal consideration leading Descartes to postulate the pineal body as the point of interaction between the *res cogitans* and the brain. It should be apparent that the Ego Point, as here conceived, is not a fixed anatomical point. It is rather a focus of excitation which moves from one part of the high level input processing areas of the brain as the focus of attention moves from one stimulus to another.

This second feed-back from the Emotion Servo into the Selective Attention Device is in direct conflict with Broadbent's statement:

The *third modification* to the older view is that the role of motives and 'drives' probably comes in the second [i.e., pigeon-holing] type of selection and not in the first and older [i.e., selective attention] type. (Broadbent 1971, p.14)

The basis for this judgment appears in the final chapter of *Decision and Stress* where he points out that

it pays to do things that bring reward and avoid doing things that bring punishment. But it pays to notice *either* stimuli which indicate reward *or* those which indicate that punishment is imminent. (Broadbent 1971, p.440)

The point that Broadbent overlooks here is that it also pays to ignore stimuli which indicate *neither* reward *nor* punishment. In other words what we would expect on grounds of functional utility and what, so it seems to me, the evidence suggests we have is not the absence of an effect of motivation on selective attention, but an effect which, unlike the effect of motivation on output selection which obeys the Law of Effect, is bi-directional in the sense that both appetitive *and* aversive stimuli are noticed. Only motivationally insignificant stimuli are ignored.

Evidence that motivation acts in this bi-directional way *both* on the Selective Attention Device *and* on the Limited Capacity Pigeon-holing System comes from the phenomenon of the nightmare or anxiety dream. It is well known that in the light of his experiences with the phenomenon of battle neurosis during the First World War, Freud was compelled to abandon the original attempt (Freud 1900) to reconcile this phenomenon with his principle that all dreams are wish fulfilments and recognise the operation in the case of anxiety dreams of the contrary principle of fear fulfilment. This, together with the phenomenon of depression, prompted his abandonment of the undiluted Pleasure Principle in his book *Beyond the Pleasure Principle* (Freud 1920) and his replacement of the single Sex Instinct with the biologically indefensible notions of two contrary and conflicting Life and Death Instincts. As far as the anxiety dreams are concerned, a biologically more acceptable explanation of these findings is provided by the suggestion that dreaming is an activity of the selective attention mechanism. For, as I put it recently in commenting on a paper by Herbert Rachlin on 'Pain' in *Behavioral and Brain Sciences* (Rachlin 1985):

Attending behavior and thinking ... both function in part as operants obeying the Law of Effect. However, both these forms of behavior appear to be subject to what we may call 'a respondent override mechanism' that ensures that attention and thought are directed as much toward stimuli that are highly aversive as they are toward stimuli that are reinforcing with respect to operant behavior. Without such a respondent override mechanism the operation of the Law of Effect would have the maladaptive consequences predicted by the now long discredited theory of 'perceptual defense' whereby the organism would systematically ignore aversive stimuli such as a pain, as well as those discriminative stimuli which act as danger signals with respect to such aversive contingencies. (Place 1985, p.71)

Not only does this quotation make essentially the same point concerning the effect of motivation on perception that Broadbent makes in the passage quoted above, when presented as an explanation of the phenomenon of the anxiety dream, it also provides additional circumstantial evidence in favour of the view that mental imagery is a by-product of the activity of the selective attention device.

Although the principal reason for introducing the Emotion Servo and wiring it into the system as I have done has been to accommodate features suggested by an analysis of our ordinary psychological concepts, there is also a considerable body of experimental evidence which supports this proposal in accounting both for the phenomena of stress discussed by Broadbent in Chapter VI of *Decision and Stress* and for the operation of the Law of Effect in bringing about and subsequently maintaining changes in behaviour over the longer term. The Emotion Servo also has the virtue of corresponding rather precisely to the known functions of the hypothalamus.

7. Broadbent's fourth modification.

"Primary memory" is no longer construed, as in 1958, in terms of the feeding back of relatively unmodified information from the output of the Limited Capacity Channel into the Short Term Store or Buffer. The Limited Capacity Pigeon-holing System is now seen as performing a much more radical transformation on the information it receives from the State of Evidence which would preclude its output from being recycled through the Buffer. In order to accommodate the observations on the strength of which this recycling was initially postulated an intermediate memory store, known as the "Echo Box" (Broadbent 1971, pp. 359 ff.) is interposed between the output of the Limited Capacity Pigeon-holing System and the Category State.

8. Broadbent's fifth modification.

The function of the Limited Capacity Pigeon-holing System in generating Category States is further elaborated in two ways:

- (a) The input side of the Limited Capacity Pigeon-holing System is further elaborated in terms of the distinction between "pigeon-holing" in which an input is assigned to an existing class of objects, events or states of affairs, and "categorizing" which, I gather from Broadbent (personal communication), is the process whereby new categories and classes are acquired and the boundaries of existing ones are extended and refined. I have tried to represent this elaboration on the revised version of the Diagram partly

- (i) by transferring the concept of 'a filter' from the mechanism of selective attention to the input end of the individual pigeon-holes or concepts of which the Limited Capacity Pigeon-holing System is now seen to be composed; it seems to me that the electronic filter is a much better model for what Sir William Hamilton (1860) called the "intension" (spelt-with-an-s) of a concept or general term - that is to say, the criteria we employ in deciding whether or not a given particular does or does not qualify for inclusion in the membership or extension of a class - than it is for the mechanism of selective attention, as was originally proposed by Broadbent in 1958;
 - (ii) by providing a feed-back loop from the output of the Category State into the side of the Limited Capacity Pigeon-holing System which represents the effect of the way previous inputs have been pigeon-holed in changing the intension or filter-setting of the concept or concepts involved on future occasions.
- (b) The output side of the Limited Capacity Pigeon-holing System is elaborated in terms of the notion that "category states each correspond not only to a class of possible inputs but to a class of possible outputs" (Broadbent 1971, p. 15). I take this to mean that identifying an input as an encounter with an object, event or state of affairs of a particular kind involves pre-selecting a class of responses appropriate to the presence of things of that kind.

I have tried to represent this pre-selection of behavioural strategies appropriate to the current State of Environment by showing the output side of the concept or pigeon-hole which is selected by the action of the Limited Capacity Pigeon-holing System as an electro-magnetic relay. The electro-magnetic relay, whose energisation has the effect of opening some circuits and closing others without necessarily producing any immediate change in the output of the system of which it forms part, seems to me an ideal model for what has been called the "categorical basis" of the onset and maintenance of a behavioural disposition, a disposition, for example, like the readiness to produce any one of "a class of possible outputs", depending upon which of a class of possible inputs is subsequently received.

9. Broadbent's sixth modification.

Broadbent proposes that the problem of how to represent the process whereby information is retrieved from the Long Term Memory Store be resolved

by showing the outflow of information from long-term memory as passing only through the categorizing stage;

He points out, however, that

if one adopts this course, however, one must remember that the category setting is itself a form of long term memory. (Broadbent 1971, p. 16)

I don't believe and haven't believed for a very long time in the existence of a Long-Term Memory Store as a discrete unit within the brain. I am glad to say that more and more people are now coming to share this disbelief in the light of the development of the Parallel Distributed Processor which has the capacity to retain information over the longer term without having a single box in which this information is stored. These considerations, together with Broadbent's own observation that

"category setting is itself a form of long term memory,"

have led me to eliminate the Long Term Memory Store or "Store of Conditional Probabilities of Past Events," as it was called in 1958, and transfer its functions to the Category State which should be regarded, not as a store of information, but as a semi-permanent pattern of circuit openings and closings resulting from the previous pigeon-holing activity of the Limited Capacity System.

But having thus moved away from a storage-retrieval model of long term memory and towards an activity-reinstatement model, there is no longer any need to account for

the facilitation and interference effects appearing in long term memory as a result of associative links between category states ... by showing the outflow of information from long-term memory as passing only through the categorizing stage.

These associative effects are readily accounted for on the activity-reinstatement model in terms of common elements shared by different category states which have been "stamped in" by previous pigeon-holing activity on the part of the Limited Capacity System. Consequently there is no longer any objection, as I see it, to showing the feed-back loop from the output of the Category State as an input into the Selective Attention Device (representing the phenomenon of expectation) as well as into the Limited Capacity Pigeon-holing System (representing the effect of past learning on such things as subsequent interpretation, recall and the formation and modification of concepts or "categorizing," as Broadbent calls it).

References

- Boring, E. G. (1950) *A History of Experimental Psychology*. 2nd. Edition, New York: Appleton-Century-Crofts.
- Broadbent, D. E. (1958) *Perception and Communication*. Oxford: Pergamon.
- Broadbent, D. E. (1971) *Decision and Stress*. London: Academic Press.
- Burt, C. (1968) Brain and consciousness. *British Journal of Psychology* 59, 55-69.
- Burt, C. (1969) Brain and consciousness. *Bulletin of the British Psychological Society* 22, 29-36.
- Churchland, P. S. (1986) *Neurophilosophy: Toward a Unified Science of the Mind/Brain*. Cambridge, Mass.: M.I.T. Press.

- Freud, S. (1900) *Die Traumdeutung*. Leipzig und Wien: Franz Deuticke. English translation as *The Interpretation of Dreams* by A. A. Brill, London: George Allen & Co. 1913.
- Freud, S. (1920) *Jenseits des Lustprinzips*. Leipzig, Wien und Zürich: Internationaler Psycho-analytischer Verlag. English translation as *Beyond the Pleasure Principle* by C. J. M. Hubback, London and Vienna: International Psycho-Analytical Press, 1922.
- Hamilton, W. (1860) *Lectures on Logic*. 2 Volumes, H. L. Mansel and J. Veitch (Eds.), Edinburgh.
- Harzem, P. and Miles, T.R. (1978) *Conceptual Issues in Operant Psychology*. Chichester: Wiley.
- Myers, C.S. (1923) The evolution of feelings. *Australasian Journal of Psychology and Philosophy* I, 3-11.
- Place, U.T. (1954) The concept of heed. *British Journal of Psychology* 45, 234-55.
- Place, U.T. (1956) Is consciousness a brain process? *British Journal of Psychology* 47, 44-50.
- Place, U.T. (1969) Burt on brain and consciousness. *Bulletin of the British Psychological Society* 22, 285-292
- Place, U.T. (1973) The mental and the physical - a reply to Dr. Meynell. *Heythrop Journal* XIV, 417-424.
- Place, U.T. (1982) Skinner's *Verbal Behavior* III - how to improve Parts I and II. *Behaviorism* 10, 117-136.
- Place, U.T. (1985) Semi-covert behaviour and the concept of pain: a comment on H.Rachlin 'Pain and behavior'. *The Behavioral and Brain Sciences* 8, 70-71
- Posner, M. I. and Warren, R. E. (1972) Traces, concepts and conscious construction. In A. W. Melton and E. Martin (Eds.) *Coding Processes in Human Memory*. Washington, D.C.: Winston.
- Rachlin, H. (1985) Pain and behavior. *The Behavioral and Brain Sciences* 8, 43-53.
- Ryle, G. (1949) *The Concept of Mind*. London: Hutchinson.
- Skinner, B. F. (1938) *Behavior of Organisms: An Experimental Analysis of Behavior*. New York: Appleton-Century-Crofts.
- Skinner, B. F. (1957) *Verbal Behavior*. New York: Appleton-Century-Crofts.
- Sperling, G. (1967) Successive approximations to a model of short term memory. *Acta Psychologica* 27: 285-292.
- Velmans, M. (1987) Why a mind/body group? *The British Psychological Society: History and Philosophy of Psychology Newsletter* 5, 8-9.
- Wundt, W. (1896) *Grundriss der Psychologie*. Leipzig.
- Wundt, W. (1897) *Outlines of Psychology*. English translation by C. H. Judd of the *Grundriss der Psychologie*, Leipzig: Engelmann.