PART III. CRT Technology at the Short-term Level of Directive Correlation

Having concluded from Part II that there is a problem with our adaptation at the ontogenic level, we turn to a perceptuomotor analysis, looking for a pattern which may explain the deficits noted.

An obvious starting point is the data accumulated from experiments designed specifically to elicit television's effects at this micro level. While this evidence can hardly be described as voluminous, it confirms suspicions and validates hypotheses of distorted cortical function while under the influence of the CRT. Because of its disappointingly meagre proportions, we supplement these results with indirect evidence gleaned from diverse sources. Of critical interest for the future of this question are the new metabolic patterning techniques which in themselves effect a transition from the reductionist paradigm towards the contextualist. Other sub-hypotheses of neurochemical disorder are derived.

Also emerging from diverse sources is a coherent picture of television epilepsy, the most dramatic illustration of the effects of the CRT upon the central nervous system. As this manifestation is rarely acknowledged, we deal not only with its aetiology, but also with its treatment and prevention, and the possibility of its wider occurence amongst the normal population as CRT technologies diversify and become common-place. A direct link is thereby made to the chapter (14) examining studies of video display units.

For an explanation encompassing the full range of reactions to the CRT, we then focus on theta wave activity. In this most controversial of fields, we find it necessary to reinterpret the EEG, clarifying the function of theta within the context of the alpha and beta wave bands in such a way that coherence is established between this phenomenon and the analysis of recognition and knowing 'of' in the previous part. Such a correspondence supports the notion of maladaption at the neurophysiological level and confirms that the CRT exerts a consistent, systematic influence on human behaviour.

We finish this third part by integrating within the debate the documented effects of VDU's in workplaces. The minor differences between domestic TV's and VDU's are discussed as they relate to the gathering epidemic of 'mildly abnormal' reactions by operators and again, in the service of a comprehensive review we must widen the terms of reference to cover the invisible energy spectra. Our analysis of theta as a modal reaction at the EEF level is paralleled, and thus checked, by the normal curve of more conventional health statistics being compiled as research data and awareness grow. We begin to glimpse how acute is our adaptation to our physical environment and the care we need to exercise in protecting those of our species who are most sensitive to its nuances, particularly those which lie outside the commonly occurring range.

Chapter II Direct Testing of Television's Neurophysiological Effect

This chapter addresses itself specifically to the direct testing of television's neuro-physiological effects. The hypothesis in question is that proposed by Emery and Emery in 1975, namely as in Chapter I, the answer to the question:"What actually takes place when a person sits down and looks at a functioning television screen?" (Emery and Emery 1980,p.27). The central dimensions of that hypothesis that television slows cortical function because of habituation and its radiant rather than reflected characteristic were overviewed as above.

But while the hypothesis has struck chords with many, there has been a noticeable non-response, and in some cases a hostile response by those in a position to test, or fund tests, of such an hypothesis. This chapter then represents the response so far (October 1983) to Krugman's original experiment and the Emerys' hypothesis that the technology (medium) diminishes our ability to process the transmitted information. Given that Western culture is now 'televized' and increasingly 'privatized'* (Pawley, 1973) and these trends are rapidly appearing across the third world, the overall level of scientific response as reported here, is disappointing, both in quantity and quality.

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*There are concurrently trends to the contrary however (Emery M.1982, Part I)

Despite this, a review of deliberate experimentation around the questions of TV's effects on the human central nervous system must be the first step in assessing the system state at the short-term level of adaptation.

1. Experimental Tests and Results

(i) Krugman, 1970, 1971

Krugman's 1970 experiment has been explored in detail in A Choice of Futures (Emery and Emery 1975,76). I will only briefly summarize that work here.

Krugman's subject displayed a "characteristic mode of response" to television which took about 30 seconds to develop and which contained elements of drowsiness. While viewing TV, fast wave activity indicating intellectual activity dropped to half the time recorded while the woman read a magazine. Slow wave activity more than quadrupled after the subject moved from the print condition to watching TV. Krugman also reported an increase in slow wave activity as viewing continued. Neither reading the magazine nor watching TV could on this data be interpreted as an 'alpha' state as the predominant response to each mode respectively was beta and theta. Differences in response to three different subject matters were minimal. "The basic electrical response of the brain is more to the media than to content differences" (Krugman, 1971 p.7)

Table 11.1 Krugman's (1970,71) Comparison of two activities in terms of percentage of time of three EEG wave bands.*

		READING HARD COPY Reflected Light	WATCHING TV Radiant Light
Slow wave:	Theta, 4-7 c.p.s. (θ)	10	46
	Alpha, 8-13 c.p.s. (α)	32	30
Fast wave:	Beta, 13+ c.p.s. (β)	56	24
	Ratio of $\beta:\theta$	5.6	0.52

This table yields the critical ratios for the patterns. Taking beta proportional to theta, as we made no specific predictions for alpha wave activity, we see the extreme nature of the demonstration.

In discussing Krugman's demonstration of our theoretical conclusions Emery & Emery (1975,76) compared his data to that of Heron (1957) whose normal subjects had been subjected to perceptual deprivation. The

*Krugman originally called the 4-7 c.p.s. band 'delta' but it is correctly named Theta. It was accurately described in the 1971 version. This published version also mentions two tests of the subject, the first with a simulated and the second with an actual TV set.

similarities in the TV and deprivation records were striking. We also searched for the closest other EEG tracing and found a normal drowsiness profile in Gibbs and Gibbs (1950). These correspondencies lead us to further speculation about the perceptual and behavioural effects of viewing, and especially prolonged viewing.

Silberstein et al (1983,p 6) have taken exception to this comparison on the ground that the two measures were not strictly comparable. They were however, both measures of the amount of various wave frequencies over time which could be converted to a comparable base. Their criticisms misses the point though, which is that at the time of creating the hypothesis there was a dearth of empirical evidence which could be used to support or reject it. Heron's data enabled us to speculate further and create specific hypotheses for direct testing. As we see below, we still await an unconfounded simple test. But Silberstein et al's own results (see below) bear out the utility of representing television viewing as perceptual deprivation.

Since that time however, other empirical studies have been performed. Neither Krugman nor we then knew that Rossiter and Schaffer had previously tested TV versus film and found "significantly lower pupillary-dilation responses to the same film presented on a TV screen than when present on a film screen even though image size and light intensity were identical." (Rossiter, 1980)

While there were believed to be methodological difficulties with the pupillary dilation approach (Goldwater, 1972) these appear to have been resolved and the response validated as an index of cortical

activation or vigilance in the classical sense of Hughlings Jackson and Head (Beatty and Wagoner, 1978). Rossiter and Schaffer's result can therefore be taken as indicative of a coherent emerging pattern of television's effects as Krugman reported that the "Nice 'N' Easy" commercial aroused no pupil dilation (1971,p5). In particular, Rossiter and Schaffer showed the way for a direct test of television and projected film as radiant and reflected light sources.

(ii) Featherman et al, 1979

Featherman et al (1979) considered Krugman's 1971 demonstration inadequate on two methodological grounds; an insufficient sample size of one subject and "failure to use a real television image for stimulus presentation" (p 10). Proceeding to overcome these difficulties they designed a study for two purposes; first to examine the EEG correlates of television viewing with reading as a comparison activity and second "to investigate whether people who watched a great deal of TV during early childhood show a different response to viewing than, people who did not watch TV when very young." (p.11) Other physiological measures were made in addition to EEG, namely horizontal EOG to indicate horizontal saccadic eye movements and some EKG monitoring of muscular tension and activity. Subjects were split into post- and pre- TV groups, matched for sex and screened for psychopathological disorders. The content of the viewing and reading conditions was not identical. On the surface then, this experiment was set up to be a definitive test of the neurophysiological differences between TV viewing and reading. The problem or flaw here involves that which we have previously noted; a blind spot for the fact that each medium has

special and defining characteristics. In this case the confusion appears between reading as an activity and reading as reading hard copy.

In order to reduce further confusion I will name each activity together with the medium used separately, such as watching pictures on TV becomes viewing TV, reading text on TV becomes reading TV etc. Projection systems will be specified precisely as to projection onto or rear projection (which latter is another radiant light source). In their desire to technically overcome the Krugman inadequacy in failing to control the stimulus, Featherman et al projected slides of reading material onto the TV screen. From their description I have concluded that this was a reflected light condition. It is therefore not a replication of a test of the difference between reading a hard copy and television viewing. Nor is it a test of reading versus viewing via television as the reading material was projected onto the screen (reflected light) while the viewing was done via the normal radiant TV source. The results are a combination of three variables; reading versus viewing, radiant versus ambient light, and two different subject matters. As such we cannot extract the particular contribution made by any one of these dimensions. Each is confounded in each condition. This would certainly help explain one of their most unexpected findings which was the lack of relationship between saccadic movement*

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*Saccades are rapid eye movements used during voluntary refixations or in response to reflex visual or auditory stimuli. They are under the control of the brain stem and perhaps the cerebellum (Spector et al, 1980).

and alpha activity. Featherman et al found that "Ss averaged between 5.7 and 9.2 times the number of saccades while reading than while watching television." (p 20) but no significant difference in the alpha band between the TV and reading conditions. This is, however, consistent with Krugman's findings. Alpha is discussed in more detail below. Certainly the huge difference in saccades between reading and watching television is consistent with other observations of TV viewing behaviour and indicated some profound difference in operating mechanism.

Unfortunately the measure used by Featherman et al, average power density spectra, is not comparable to that of Krugman and we cannot derive similar beta to theta ratios from it. Their findings in relation to changes in each of the bands employed are however, partially supportive of Krugman's conclusions. "A significant decrease in both theta and beta 1 activity ($p < .05$) occured during the television versus the reading condition, suggesting a reduction in cortical arousal during TV viewing." (p2 with my emphasis). The beta 2 (faster) band did not show a significant difference between the conditions but this may be related to the elevated level of theta found in this and some other studies of reading. The theta phenomenon which emphasises the range of individual variability and causes difficulties with its interpretation is discussed in more detail below. Presumably, Krugman's subject was not one of those to show theta activity while reading.

As Featherman et al note, an inadvertent finding led them to conclude that the EEG showed some response to the content of the program.

During the minutes 20-25 there was a decrease in the power of alpha and a rise in each of the other three frequency bands. Sixty-five percent of their S's showed this pattern. This is evidence for the power of some particularly alerting content to change the cortical arousal level while viewing, for some people. It may have been the sexual overtones as they interpret, or perhaps this segment contained a higher degree of alerting technical events such as are used in the production of advertisements. (Mander, 1978, Price, 1978)

Featherman et al noted (p 18) that "a significantly higher amount of theta activity was observed in the left hemisphere across all conditions." This was the only hemispheric difference. No effect of early childhood exposure to television could be detected. No data are provided on the EKG monitoring. Similarly, no data are given on the range of individual variability.

(iii) Work of the Weinstein team

The Weinstein team has also explored the question. In their first report (Appel et al, 1979) they concentrate on the activity of the alpha band in relation to twenty four hour recall and in the second (Weinstein et al, 1980) on the beta band. In both cases the subjects were 30 right handed women. The first study was restricted to television commercials and is not therefore a comparative test of the nature of projected and radiant media. The results though are instructive. They found significantly more alpha activity generated by the blank screen than by the commercials which indicates the influence of content as well as medium, contrary to Krugman.

The maximum difference in percentage of alpha activity between the average for the blank screen episodes and the commercial trials was 6.1% or a 33.2% increase when viewing screen alone, and the correlations between the blank screen average and the commercial trials were all significant at the $p < .01$ level. Screen and content were obviously both playing a role (from their Table 3). There was also little difference in the percentage of alpha between the pre- and post blank screen epochs which indicates negligible transfer of effect from the content sessions onto the alpha band.

Appel et al stress the influence of individual differences in the generation of alpha which "had nothing to do with commercial content" and "that these differences tend to persist across the two hemispheres. The range of inattentiveness while watching the commercials was about 3 percent to 43 percent of the time for individual subjects" (p 10). To overcome this difficulty they computed a 'total activity index', the use of which showed some evidence for the hypothesis that high recall commercials generate higher activity and confirmed "that the television commercials that produced the greater amount of brain activity regardless of hemisphere also produced the greater amount of advertising recall."(p 13)

The failure of their data to support the hypothesis that television is a right hemisphere activity was challenged by Krugman and they subsequently reanalyzed as he suggested. Using the total means for each of the three trials they found that "left dominance declined exponentially over time" (Krugman 1980, p 66)

Krugman continued "A gross total record of brain activity over time showed that the left hemisphere tires and gives way to the right... (People) will eventually tire to the point of achieving 'natural' viewing with the left hemisphere relatively 'turned off' and the right hemisphere remaining alert." Krugman's accurately directed questions to the Weinstein team arose from his 1977 hypothesis that the role of the right hemisphere is constant vigilance or reconnaisance for features to which the left should be alerted and attentive. Diamond and Beaumont (1973) whose work Krugman had studied, found evidence for two vigilance systems; a primary one "characterized by high initial performance coupled with exhaustibility at the left hemisphere, and second order vigilance showing a lower level of performance without general decrement at the right hemisphere." (p 264).

Weinstein et al's second study compared TV and magazine advertising to test three hypothesis building on the previous results. As with Krugman and contrary to Featherman et al., the magazine ads were presented on paper. This study therefore constitutes a genuine comparison of the paper and TV media but as Krugman pointed out (1980, letter to the editor, p 63) it cannot be determined that the subjects were actually reading the print on the magazine ads. But as a media comparison the results are unambiguous. Table 11. 2 presents an integration of Weinstein et al's Tables 1 and 2 rearranged for greatest effect here.

Table 11.2 Percent Beta Activity while viewing Magazine and Television. (Means only)

	TV			MAGAZINE		
	With Content	Blank Screen Post-test	Pre-test	Blank Page Pre-test	Post test	With Content
L.H.	54.5	57.0	57.1	60.6	63.1	63.7
Differences*	2.5	2.6	6.1	8.6	9.2	
R.H.	54.8	57.9	56.2	62.3	60.5	62.0
Differences	3.1	1.4	7.5	5.7	7.2	

*Differences for each medium calculated from the 'TV content' percentage as baseline.

Thus arranged this table not only displays Weinstein et al's findings as reported, it also illustrates more clearly the psychological progression from one medium to the other. There was "a higher level of beta activity in both hemispheres when the subjects were viewing the magazine advertising than when they were viewing the television commercials...(and this) difference...was not entirely related to the content of the two media... The subjects also exhibited more beta activity while they were exposed to the blank magazine page than while they were exposed to the blank television screen." (p 59). About their table 3, mean percentage-point differences in beta activity, they comment "subjects exhibited a higher level of beta activity (+3.1) while viewing the magazine advertising than while viewing the blank page. But in the case of television, we observed the reverse pattern (-2.6)" (p.59). The net difference was highly significant.

Laterality results are not quite so clear but there was an indication that relative amount of left-brain activity increased as the subject(s) was (sic) viewing the magazine advertising (p 60). My table 11.3 illustrates the trends.

Table 11.3 Trends in Lateralization for Television and Magazine (from means presented in table 11.2 above).

	TV			MAGAZINE		
	Blank-pre	Content	Blank-post	Blank-pre	Content	Blank-post
Ratio LH/RH	1.02	.99	.98	.97	1.04	1.03

Left brain activity declined while watching TV and increased while looking at the magazine. Had there been no omissions in the analysis of this data (see below) these trends may have appeared more strongly, i.e. without contamination from the order of presentation; TV or magazine first.

The relationship between media and content is illustrated in their Table 5 from which they draw two conclusions "(1) regardless of hemisphere, every magazine ad produced more brain activity (beta) than did any of the television commercials, (2) there was little variation among the ads or commercials" (p61)

About the first conclusion there can be no argument. For the two commercials shown on both media which gives comparability of content, the percentage increases in beta are shown in table 11.4

Table 11.4 Percentage Increase in Beta for Comparable Content for Magazine Relative to Television

	Left Hemisphere	Right Hemisphere
Brand A	12.3%	16.1%
Brand B	15.1%	14.8%

For the second conclusion however, it depends on how one reads their Table 5. If we present this data in the following form (Table 11.5) it shows that there was a greater variation in beta activity for the magazine rather than television.

Table 11.5 Range of Percent Beta Activity for Comparable Content in Magazine and Television

	Left	Right	Over Both Hemispheres
Magazine	5	7	8
TV	4	2	4

For the left hemisphere the range was 25% greater; for the right it was 250% greater. This has significance for the thesis here. We would expect less variation in the levels of beta activity while looking at ads on TV rather than on paper because of the generally decreased level of activity. In other words the subjects would be less sensitive to the commercial messages and their differences. These thirty subjects appear to have discriminated more between varying content on paper than TV.

Thus the magazine ads produced not only more overall beta but also greater variability in activity in relation to changing content.

Correlation between recall and activity gave mixed results. "Although the relationship was confirmed in the case of the print advertising for those subjects who appeared most responsive to differences in the advertising treatments, such was not the case either in the comparison between print and television or among the television commercials themselves." (p 62). They saw the reason for the failure of the magazine ads to produce higher recall levels despite greater beta activity as 'unclear'. There is perhaps a reason as discussed below.

It is unfortunate given the sparsity of the literature in this area that neither of the Weinstein studies report the full range of frequencies. The relative levels of activity for beta, alpha and theta would have tended to confirm either Krugman's or Featherman et al's differing results*. It would also perhaps have shed more light on the laterality and recall results.

A more serious omission in terms of this study is the failure to analyse by priority of presentation. If television produces a learning 'not to respond' there will necessarily be an extinction curve (Emery & Emery, 1975,76 p 79-83).

For those who saw the television commercials before the magazine, the beta activity during the magazine viewing should have been lower than

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*The author rang Dr Sydney Weinstein in case this data was available for analysis but it was not kept.

for those who saw magazine ads first. Given the degree of support already found for the general hypothesis the possibility that such was the case cannot be dismissed.

Assuming that there was contamination by transfer of effect we can more readily understand Weinstein et al's difficulty in establishing laterality and correlation between recall and beta activity. No such effect was possible in their previous experiment and in that case these difficulties were not struck. We would expect that if the analysis had been conducted with this possibility in mind the results for percentage beta activity would look as follows:

Beta Wave Activity

Higher: <——————————————> Lower

Magazine first, magazine second, television second, TV first

Placing the TV first condition at the lower end is based on the assumption that looking at a magazine is an activity more stimulative of beta than simply being in a normal day-to-day perceived environment.But given the assumed power of the television medium to lower activity this is a small point. The trends displayed in Table II.3 would then have shown a significantly increased increment in the LH/RH ratio for the 'magazine first' condition over time and a lesser effect for 'magazine second'. The two television conditions may also have differed in magnitude of decrement of LH/RH activity over the duration of the viewings.

Lack of clarity in the relation between activity and unaided brand recall would have been similarly overcome. We would expect lower recall from the 'magazine second' group than from the 'magazine first'. Even though magazine viewing clearly generated more beta than television, a period of TV viewing following the magazine condition may have been sufficient to cancel the effect on ability to recall. The short term memory deficit associated with television viewing may also operate on material viewed via another medium immediately prior to the TV episode.

Using an all women sample may have introduced systematic biases into the results. See Chapter 4.

(iv) Walker, 1980

In 1980 Walker published the results of a preliminary study of reading hard copy, watching television and four other tasks commonly employed in psychophysical research. Subjects were 18 young (17-35) right handed students (9 males and 9 females). Conditions and instructions were as follows:

Resting eyes closed -

"Close your eyes and relax. Try and clear your mind of any thoughts. Relax your muscles, and let them go limp. Try and focus your attention and concentration on your breathing";

Imagine beach -

"Open your eyes and look at the blank TV screen. Try and relax and form a mental image of yourself quietly sitting on a beach. Watch the waves coming in. Look at the mental image you have of the waves coming in";

Television -

"Relax and watch some television";

Resting eyes open-

"Keep you eyes open and look at the blank TV screen. Clear your mind of any thoughs, relax your muscles and focus your attention and concentration on your breathing.";

Reading-

"Please reach the book next to you, open it to the marked page, place the book comfortably on your lap and begin reading.";

Counting backwards -

"Keep your eyes open and look at the blank TV screen. Starting with the number 972, please count backwards by units of 3."

The television tape was recorded in color from a daytime "talk show" (Walker 1980, p 256)

Content and medium cannot be separated but the emphasis throughout was on 'relaxation'. Unfortunately, Walker recorded only alpha and beta wave activity and this is puzzling as he specifically notes Krugman's use of slower frequencies. He presents means and S.D.'s for both sexes at left and right occipital sites (01 and 02) and as the following Tables show, the pattern is highly consistent.

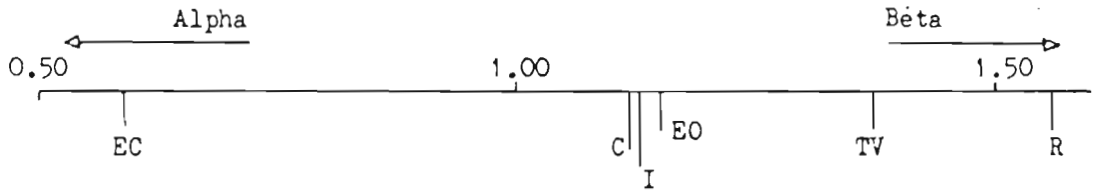
Table 11.6 Rank Order of Means for Alpha and Beta Band + Ratio of Beta to Alpha across all conditons. (from Walker, 1980, tables 1 and 2)

	Alpha		Ratio	Beta	
	Total Sample	Average Rank Across Sex & Site	$\beta:\alpha$	Total Sample	Average Rank Across Sex & Site
Reading (R)	6	6	1.56	1	1
Television (TV)	5	5	1.37	2	2
Eyes Open (EO)	3	2.5	1.15	3	3.5
Imagine (I)	2	2.5	1.13	4	4
Counting (C)	4	4	1.12	5	4.5
Eyes Closed (EC)	1	1	0.59	6	6

The correlation between the ratios of beta to alpha and the rank ordering for beta is almost perfect and that between the ratios and rankings for alpha only slightly less so.

Figure 11.1 illustrates the range.

Figure 11.1 Range of Ratios of Beta to Alpha (Walker, 1980)



Taking alpha first, because it is of lesser (and more equivocal) significance to the hypothesis under review, there was more alpha during EC than any other condition. There was more alpha during imagine (I) than during reading (R) and more during eyes open (EO) than during R or TV. More alpha occurred during counting (C) than R, "although the mean alpha observed during TV was greater than that observed during reading, the difference did not reach significance at the 0.05 level" (p 259)

Here are the other two critical comparisons that did not reach significance. There was no difference in alpha between either I or C and TV. That is, in terms of alpha frequency, watching television could not be distinguished from relaxing, watching a blank screen and forming a mental image of sitting quietly on a beach while the waves roll in. Nor could it be distinguished from watching a blank screen while performing a totally automatic, routine mental function.

Turning to the beta band we find more beta during R than during any other condition with the exception of TV. More beta occurred during TV than during EC or C; more occurred during EO than EC and there was more beta during I and C than when EC. The other comparisons which were not significant include:

(i) EO could not be distinguished from either I or C. Neither of these mental functions produced any more fast or intellectual activity than relaxing, watching a blank screen and attending to your breathing.

(ii) TV could not be distinguished from either I or EO. In other words, television produced no more fast wave activity than relaxing and watching a blank screen or having a day-dream. It produced only slightly more intellectual activity than the (for most people) overlearnt, rote activity of counting. Remember that reading did produce more beta activity than all these other functions. The fact that the difference between R and TV narrowly failed to reach significance can be accounted for as Walker suggests, by the relatively short times recorded over each condition which are not representative of "more typically sustained intervals of reading and television viewing" (p 260). His analysis epoch was only 20 seconds, less than the 30 seconds quoted by Krugman to mark the onset of the 'characteristic mode of response'. Given this, it is perhaps significant that the gap between reading and TV was as wide as it was.

(v) Silberstein et al, 1983.

In 1983 Silbertsein et al made public the results of the experiment requested by the Australian Senate Standing Committee on Education and the Arts, in 1978. The request was made after the Emerys gave evidence concerning their hypothesis and its supporting data. The experiment was intended therefore to be a direct test of the hypothesis outlined. Using 12 males and 12 females, all 13 years old, normal and right handed, they tested EEG responses across four band widths: delta (1.5-3.5 Hz) theta (3.5-7.5Hz) alpha (7.5-12.5 Hz) and beta (12.5-25 Hz). The purpose was "to ascertain whether television viewing, regardless of content, alters the frequency composition of the ongoing EEG leading to an increase in delta, theta and alpha activity and a corresponding decrease in beta activity." (p 10) Despite the careful technical work however, the design was fatally flawed and could not provide such a test. It does, however, provide some excellent evidence on the effects of the act of television viewing on children.

The study used four conditions, three employing a TV monitor and one a back projector. This latter is a radiant light source. Four different contents were also employed: Text was used in the rear projection and one TV condition and the other two TV conditions consisted of an interview and a documentary. While the tests were judged (by adults presumably) to be 'equivalent' they clearly were not identical. At this most primitive stage of our understanding of what affects the CNS, the two texts would have to be called 'different'. The study is therefore of four radiant light media with four different contents.

Silberstein et al followed Featherman et al in failing to distinguish between different media. But in this case the omission is more difficult to understand. Their bibliography contains two papers which argue for clarity in thinking about media and discuss the radiant light hypothesis. (Emery and Emery, 1980; Emery M. 1981) Is it possible that they designed their study before reading the literature? Also, the Emerys were not, at any stage, consulted about the design. In addition to this, the data testing was done in a way that did not touch upon the central emphasis of the stated purpose; the increase in slow wave activity and the corresponding decrease in fast, beta wave activity. Relativities between slow and fast were ignored and replaced by within-wave band tests of differences. Means and SD's were provided though, which allows us to reconstruct simple ratios of fast to slow frequencies over both viewing and non-viewing conditions. Each subject underwent nine testing conditions; five identical non-viewing conditions and four different viewing conditions lasting three minutes each, in a non-viewing then viewing sequence. During both viewing and non-viewing conditions S's were instructed to watch the screen (p 12).

Critical questions of the data then become:

(a) what are the relative dominances of the wave bands while watching radiant light,

(b) are these relative dominances significantly different from those found during non-viewing, and

(c) to what extent was content significant?

We would expect on the basis of the Emery hypothesis and previous empirical evidence that:

(a) each of the four viewing conditions would show a relative predominance of slow to fast wave activity

(b) there would be greater slow wave and less fast wave activity in the viewing rather than non-viewing conditions, although over the total period of the experiment the ratio of slow to fast would increase in the non-viewing conditions, and,

(c) there would be some, but no great, influence due to content differences. Commercials are now routinely checked for content which will be alerting and interesting (Weinstein, 1982).

The following results are those obtained from the occipital cortex only. Silberstein et al report that they could not detect any significant differences in relative power in any band-width at the temporal and frontal sites of either hemisphere (p 18). This is in itself a highly significant finding. All of the authoritative sources used by Emery and Emery (1975, 76) stressed the critical importance of these lobes for the derivation of meaning and consciousness. The significance of the Silbertsein et al content was simply not registering in the brain area which defines and controls our human-ness. Silberstein et al claim that the Emery argument for habituation to the TV signal is untenable because the content, perceived picture, is a "continually varying image of <u>potentially meaningful</u> information" (my emphasis). "The stimulus must be the picture and, more importantly, its meaning, rather than simply the myriad of microscopic flashing lights which constitute the picture" (p 27-28)

Given their lack of results in the frontal cortex it would appear that the word 'potentially' was well chosen. As we will see later with Schafer's study, the interest in the pictorial stimuli can paradoxically enhance the habituation effect of the medium. The possibility of the medium itself having stimulus properties is the matter at issue; and is not one to be settled by 'obiter dictum'.

Taking (a) first, the relative dominances of the wave bands, let us examine the extreme case of the ratio of beta to delta. While there are problems of interpretation with theta and alpha (see below) the literature contains no such serious problems with either delta or beta, and these are the normal extremes. If there is to be a clear cut difference in the ratios due to content, it should be unambiguously present in this analysis. Using this measure Table 11.7 shows that while watching radiant light we find the following:

Table 11.7 Ratios of Beta to Delta means over four Conditions for Both Hemispheres (From Silberstein et al's Table 2,p 19)

	Projected Text (PT)		Televised Text (TT)		Television Interview (TI)		Television Documentary (TD)	
	RH	LH	RH	LH	RH	LH	RH	LH
Ratio, B:D	0.53	0.49	0.46	0.43	0.53	0.51	0.41	0.46

This table II.7 shows that delta wave power was running at around twice that of the beta range over all possible combinationa. In no viewing condition was there a reversal of the dominance of slow wave activity. For neither hemisphere in relation to any of the contents

was there a sign that television viewing, or viewing radiant light had the power to spark sufficient beta activity to indicate predominatly intellectual activity. This is a very poor outlook for a medium which claims to be educational. Silberstein et al can state that "subjects were observed to be awake throughout the recording session... did not appear to be in a drowsy or low arousal state" (p 23). But the fact remains that they did not cite a study which gives evidence for delta wave frequency as an active alert state.

A whole range of altered states of consciousness does exist and many have been measured, similarly and as precisely, where S's have their eyes open and are yet 'distracted'. (Emery & Emery 1976, p 74). Surely a medium so acclaimed for its ability to teach and educate should have in one viewing condition at least, shown an ability to produce the hallmark of intellectual activity; a relative dominance of beta-wave frequency.

This table 11.7 also shows that with the exception of the condition TV documentary (TD), the left hemisphere was lagging slightly behind the right in degree of activity. Krugman's explanation above about the tiring of the left hemisphere has received some minor confirmation. The condition TD, by effecting some minor shift in dominance may indicate a minor influence of content, but it was nowhere near sufficient to upset the major finding - nothing shown via radiant light in this experiment could move the pattern from passive to active.

Thirdly, comparing the columns for Projected Text and Televised Text we can see that in both hemispheres the PT enjoys a marginal advantage

over the televised conditon. As both are radiant light sources the difference could be evidence supporting the habituation hypothesis. New research on the effects of fluorescent lighting reported in the Chapter 12 on Television Epilepsy certainly confirms a basic neural response to radiant light. This explanation is more valid than one appealing to content differences in the two texts as there is overall in this study, little evidence of the power of content to determine the cortical response.

Moving now to (b) we consider Tables 11.8 and 11.9

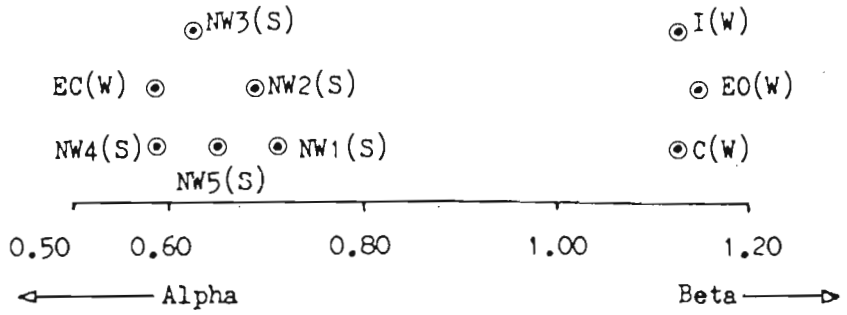
Table 11.8 Ratios of Beta to Delta means over Four Conditions and the Preceding Non-viewing Period, for both Hemispheres. (From Silberstein et al, 1983. Appendix A) Where: P=preceding non-viewing period, D= during treatment condition.

	Projected Text		Televised Text		TV Interview		TV Documentary	
	P	D	P	D	P	D	P	D
RH.	0.44	0.52	0.47	0.46	0.47	0.53	0.51	0.41
LH.	0.41	0.49	0.44	0.43	0.40	0.50	0.52	0.47

This data is equivocal. For both hemispheres the ratio of Beta to delta is higher and lower in half of the conditions than for the previous non-viewing period.

However, in this particular experiment we should not perhaps expect too much movement in this direction because the base levels for slow wave activity were almost unbelievably high. Silberstein et al do not comment on this but that 24 thirteen year olds would be showing such levels of delta frequency in an experimental, highly novel setting, is remarkable. Its remarkability is illustrated in Figure 11.2.

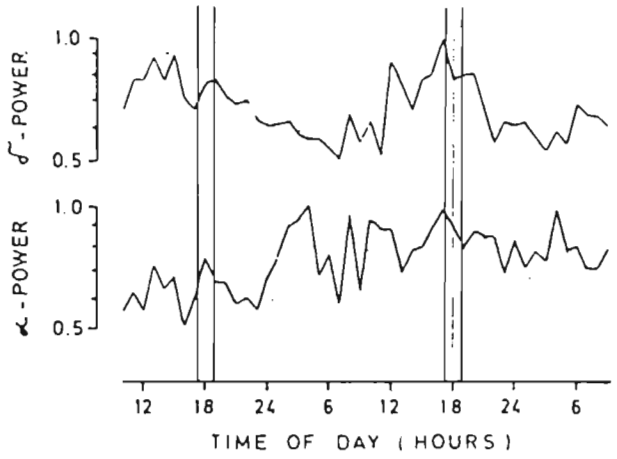
Figure 11.2 Comparison of Beta: Alpha Ratios for Silberstein et al's (S) Non-Viewing Periods and Walker's Non-stimulus conditions(W)



Using the only reliable comparison in previous studies Figure 11.2 shows that Silberstein et al's beta and alpha ratios for the five non-viewing periods were closer to Walker's 'eyes closed'(EC) condition than his 'eyes open" (EO) and daydreaming conditions. Non-viewing period four in fact showed the same ratio as EC. Had we reasonable comparisons for slower wave activity the contrast could be expected to be even more extreme.

A recent study of the circadian rhythm in the EEG may throw some light on these results. Gundel and Witthoft (1983) have shown that delta power has peaks at around 5-7 pm. Alpha also peaks at this time (see Figure 11.3)

Figure 11.3 Circadian Rhythm in the EEG. (from Gundel & Witthöft, 1983, Fig. 1 p 290)



As the authors note, "the circadian rhythm in the waking EEG has serious consequences for most of the clinical and pharmacological research on EEG" (p 291).

Borbely (1978) has also discussed the non-parametric effects of light. Any effect is governed in part by its phase relation or time relative to the circadian rhythm. There are critical periods within various periodicities when light will elicit a maximal response. Given what has already been learnt of the importance of the transitions between light-dark and dark-light, it may well be that these in the normal environment are critical periods for responsiveness to artificial light in the human system. 5-7 pm would classify as a transition and therefore critical period.

Returning to the data we note however, that although the differences are small, it was televised text and documentary that show a lower ratio in the during (D) than preceding (P), non-viewing condition. From the description of the contents, the documentary was clearly of

greater 'informational' value than the interview with the pop star. Yet the ratios moved not towards, but away from, the 'information'. Note also the reversal of direction in the two text conditions. If we grant that the two texts were 'equivalent' in the dimensions of interest and/or difficulty, then again the Projected Text showed an an advantage over the Televised, gaining further support for the habituation hypothesis.

What we can safely conclude though is that not one of the four conditions (contents) not even the documentary or the two texts was sufficient to substantially raise the level of activity from that induced by relaxing and staring at a blank turned off TV screen.

Examining the trends over the non-viewing periods themselves we find (Table 11.9) that there was a tendency for the ratio of beta to delta to decrease over time.

Table 11.9 Radio of Beta to Delta Means over 5 Non-viewing Periods for both Hemispheres (from Silberstein et al's Appendix C)

Non-viewing Period	1	2	3	4	5
RH	0.49	0.50	0.47	0.43	0.46
LH	0.45	0.47	0.45	0.40	0.43

The trend displayed in Table 11.9 is not dramatic for probably the same reason; the high basal levels of delta, but it is evident. Higher readings in non-viewing period 5, after the testing was complete may be an anticipatory response to finishing up and leaving, returning to the real world. The ratios at period 5 however, were still lower than at the beginning and at period 3.

So far this analysis provides some support for the hypothesis that viewing via radiant light induces passivity, and certainly that it does not have the power to disrupt such passivity when that is already present. Content differences so far have appeared to be minimally effective. Focussing on these specifically, we find Silberstein et al stating "there was a content-specific effect on EEG at right and left occipital sites" and that "the Emery proposition was not confirmed, in that no medium specific effects were found" (p 2). To what extent is this statement justified? (point (c)).

The most dramatic instance of lack of influence of content is of course the failure to find any differences in the frontal lobes p 18). Second, we have in their Table 1, and on p 21 their findings that "there were no significant differences in relative beta activity between viewing conditions on either the right or the left hemisphere", even in the occipital cortex. As there appears to be no dispute in the literature that beta waves are a solid indication of higher mental or intellectual process, this failure can be interpreted only as a sign that the four contents were not significantly differentiated either from non-viewing, or from each other, by the twenty four brains. In other words, the contents made no difference to the dominant level of activity.

The precise differences due to content are given in their Tables 1 and 3. Table 1 shows that 5/8 (62.5%) of the possible differences between means of the viewing conditions, adjusted for preceding non-viewing period, were significant. Note that these are only within band tests; they do not attempt to show the overall pattern of brain

activity, even though that is what they quote as the commissioned purpose of their study. Their Table 3 presents the results of paired comparison tests for the two text conditions, TV text versus TV Interview and TV Interview and Documentary conditions. Once again these are only within band-width tests but the proportion of significant findings is reduced even further. My Table 11.10 summarizes thes "strong" (p 29) findings for the power of content.

Table 11.10 Number of Significant Differences for Within Band-width Tests (from Silberstein et al's Tables 1 & 3, p 18 and 20)

	Over All Conditions (Table 1)		Paired Comparisons of Conditions* (Table 3)					
			PT vs TT		TT vs TI		TI vs TD	
	RH	LH	RH	LH	RH	LH	RH	LH
No. of Significant Differences over 4 band-widths	3	2	0	0	2	2	2	0

*of the six possible combinations here, results are presented for only three by Silberstein et al.

The left hand side of Table 11.10 shows that while in the overall covariance 5/8 differences were found to be significant, only a meagre 6/24 (25%) were found in the paired comparison tests reported. Presumably the other three comparison tests were not reported because visual inspection showed that the procedure would be unproductive. This would have given us an estimate of the influence of content at 12.5%. This is hardly "strong" evidence for the importance of content. Note also that:

(i) in every single band width, projected and televised text could not be differentiated in either hemisphere;

(ii) there were no results in the beta band;

(iii) televised interview and documentary could not be differentiated in any band in the left hemisphere, and;

(iv) the only two consistent results, rather than non-results, involved the theta and alpha bands in the TT vs TI condition and the interpretation of these frequency bands is still controversial

The study appears in toto, to resemble some other famous examples in TV research of non-significant differences (see Case No. I) and some other examples of incongruence between tables and text (see Case No. II). Perhaps the power of television does lie in its ability to distort reality!

Discussion

Silberstein et al, 1983, is the most recent empirical test in the literature. Let us clear up a few loose ends in this study before summarizing the position to date.

(a) No correlation was found by Silberstein et al between expressed interest in the various contents and EEG measures. The great hope of pro-television researchers for some time has been to find such a

correlation - after all, 'it stands to reason'. The concept of interest lay behind the pilot study of children and EEG by Mulholland (1974). Assumptions that intrinsic interest would produce fast wave variations were not supported (Mander, 1978, p 209-210). Silberstein et al's result is therefore consistent, as it is with their failure to obtain differences in the frontal lobe and in beta wave activity. Some confirmatory evidence for the power of interest has however been provided by Schafer (1978) but is subject to various interpretations. Using three sets of high vs low interest contents, Schafer tested the reactions (evoked potentials) to a flicker probe stimulus inserted in the TV picture. This flicker caused a momentary brightening of the screen which was subliminal for most subjects. In each case the amplitude of the late components of the EP's was smaller in the high-interest half of the comparison than in the low-interest segment. On the surface it is thus clear that high interest in content had an effect - it increased the habituating effect of viewing. But what did it mean for everyday viewing of TV? Schafer clarifies this. Eye movement did not differ between the high and low interest segments. (cf. Featherman et al, above). Also, two of the three high interest conditions contained explicit erotic material which normally produces increased CNS arousal which normally produces augmented EP amplitude (p 75). Certainly one can argue that eye movements and erotic arousal cannot account for the reduced EP amplitudes, but one can also argue that watching high interest (erotic) TV produces a reversal in the normal arousal process. That is, the more interesting or erotic, the less normal sexual response is produced, and in general, the less there will be reaction to extraneous stimuli. Sources used by Schafer to explain his results suggest a mechanism exactly in line with that

proposed by Emery and Emery (1975, 76) and supported by Eccles (Emery and Emery, 1980). Reduction in EP amplitude occurs where there is a marked increase in ongoing single cell activity in the association cortex in cats (Tompson and Bettinger, 1970, used by Schafer, 1978, p 76). In other words, when processing capacity is already at or close to maximum, responses to extraneous or distracting stimuli will be reduced. As people appear not to have the frontal cortical capacity to process all visual stimulation received by the primary visual cortext, there must be adaptive mechanisms to prevent overloading. "One might suggest a similar neurophysiological explanation for the reduced television-evoked potential amplitude noted during programs of high interest (Schafer, 1978, p 76). Thus while 'interest' does appear to make a difference, its investigation has provided support at the level of mechanism, for the hypothesis that television induces a maladaptive response to the natural environment. It has also provided further support for the habituation arm of this hypothesis.

The results of Schafer's study involving material which is interesting or sexually arousing (under normal conditions) may well confirm the suspicion of some observers (personal communication) that some Asian governments have rushed into television because it appears to have contraceptive properties. The one night baby boom in New York city after the electricity failed has been put down to boredom, but may be due to increased awareness of the real, human rather than TV, environment. As the human system does function as a system (as in Chapter 4) we would expect that lowered CNS activity as manifested in the predominance of slow wave activity would affect hormonal levels and other pheonomena related to sexual interest and capacity.

Under conditions of continuous light, female rate show continuous oestrus and there is some evidence that it affects the human cycle, (Dewan, 1967). Certainly in the animals tested so far, lesion of the suprachiasmatic nucleus (SCN) abolishes circadian and other rhythms, including gonadal response to photoperiods, (Borbely 1978, p 19). This structure may be a basic pacemaker for the oscillators driving the rhythms and regulating reproductive functions. A key biochemical link appears also as serotonergic mechanisms have been strongly implicated in the regulation of sleep and the SCN exhibits an exceedingly high concentration of 5 HT (as above, p 20). It appears likely that the light-induced reduction of motor activity, in nocturnals, may be related to the activation of the serotonergic system as a sufficient but not necessary condition for reducing activity and inducing sleep. Some evidence exists for an extrapolation to the human system, (Borbely, 1978, p 21).

Melatonin, a pineal hormone acting on the pituitary, plays a role in the maturation and cyclic activity of the human sex glands and is directly tied to a daily light cycle. "When melatonin is administered experimentally, it has several effects on the brain: it induces sleep, modifies the electroencephalogram and raises the levels of serotonin... In addition melatonin inhibits ovulation and modifies the secretion of other hormones", (Wortman 1975, p 76).

While a television-contraceptive link must remain speculative until empirical testing is performed, it remains a distinct possibility.

(b) Weekly amount of TV viewing was not found to be related to EEG responses in Silberstein et al's study. This supports Featherman et al's finding but the problem here is similar to that of safe levels of radioactivity. What is a safe minimum? (See discussion of VDU's, Chapter 14). As the minimum viewing reported by Silberstein et al's subjects was 7 hours per week this may be sufficient to set in train an automatic slow wave response. Is it possible that the response becomes so conditioned (Rossiter, 1980) that when the 13 year olds were asked to sit and relax in front of the blank screen at 5.00 pm, they produced their daily automatic 5.00 pm TV viewing slow wave behaviour? This might help account for the elevated delta readings.

(c) There is a very serious question about the advisability of attempting to remove EOG and EMG 'artifacts'. What is required is a test of the differences in the activity of the perceptual system between watching television (radiant light), watching a film (ambient light) and reading hard copy (ambient light) as natural behaviours. The human body works as a system; there is no such thing as a disembodied cortex (Gibson, 1966, Emery and Emery, 1976). Observational evidence shows that while reading, people move their eyes, hands, wriggle etc. and while watching TV do far less of these things (Winn, 1977, Dunn 1977). This stillness is part and parcel of the television syndrome. Mulholland commented on a pronounced relaxation of the facial musculature that he noticed while children viewed television in his laboratory (Mulholland, 1974, p 14). Colloquially, this syndrome has spawned a heap of derogatory terms (Mander, 1978, p 158, Emery M, 1982). The 'artifacts' that EEG methodologists try so hard to eliminate (Silberstein et al, p 14) are a valuable fraction of the evidence

Basically at issue here are conflicting paradigms or root metaphors (Pepper, 1966). Those in the mechanistic tradition have postulated a concept of 'cognition' which has over time become reified. To isolate the correlates of this pure function has now become a major research priority and the papers written by its advocates appear more concerned with the niceties of methodological sophistication than with human behav-iour.The widening gap between behaviour and such pure research is illustrated by Gevins et al (1979(a),(b) and (c)) who succeeded in controlling for the 'contaminating' variables of stimulus characteristics, limb and eye movements and performance-related factors such as subjects' ability and effort. Before the successful effort at 'decontamination', differences between a widely various set of tasks had been found (Gevins et al, 1979(a)). Success brought a set of non-significant differences in the EEG profile between these diverse tasks (Gevins et al, 1979 (b&c)). 'Cognition' failed to reveal itself. In addition, this team has, by controlling all behaviour extraneous to 'cognition', succeeded in proving that the hemispheres do not make differential contributions to human behaviour. This issue is discussed in more depth below. Most of the studies used in this work have been or would be critised on methodological grounds (Gevins and Schaffer, 1980) but the contextualist metaphor identifies the need to look for consistencies and patterns in behaviour as ecological realities rather than as 'artifacts'. A similar point has been emphasized by Walter et al (1976) who preferred to study their S's in 'real life' settings "since we do not normally live in an environment viewed tachistoscopically by light flashes or similarly uncomfortable brief sensory influxes". We live in a continuum within which our brains are continuously involved in 'housekeeping' processes. The pure approach

has proven of limited value in adding to our understanding of cerebral mechanisms (Walter et al, 1967, p 378). But as there appears little chance of convincing these methodological specialists on this point (Gevins et al, 1977) it is perhaps time to move television research towards the new techniques which may better encompass the ecological paradigm. (See below for discussion of nuclear techniques)

(d) Silberstein et al's study produces some evidence for hemispheric differences in response to radiant light which support Krugman's interpretation as above. Table 11.11 summarizes these.

Table 11.11 Left Hemisphere Dominance of Cortical Activity over Four Viewing Conditions and Five Non-viewing Periods

	Non-viewing (from Appendix C)	Viewing (from Table 2)
Delta	5	3
Theta	3	1
Alpha	0	1 (and one tie)
Beta	1 (and one tie)	1

The numbers express the number of times the left hemisphere showed greater activity than the right in that wave band. Clearly the left hemisphere produced more slow wave activity than the right over both viewing and non-viewing conditions. This is consistent with previous findings. Sex differences and their relation to laterality are not mettioned by Silberstein et al. There is however evidence for such a relationship (Springer and Deutsch, 1981).

However, while gender and laterality have excited some industry interest (Krugman, 1979) and caused some problems of interpretation in television research (Rossiter, 1980,81), they should clearly now be accorded a secondary emphasis. Silberstein et al's failure to produce convincing evidence in either hemisphere for television's role as an active intellectual medium has obvious priority in social science over the relative influences of the two brains. Gender and laterality may be no more than contributions to or reflections of, the role of personality in the effects of television as was explored in chapter 4.

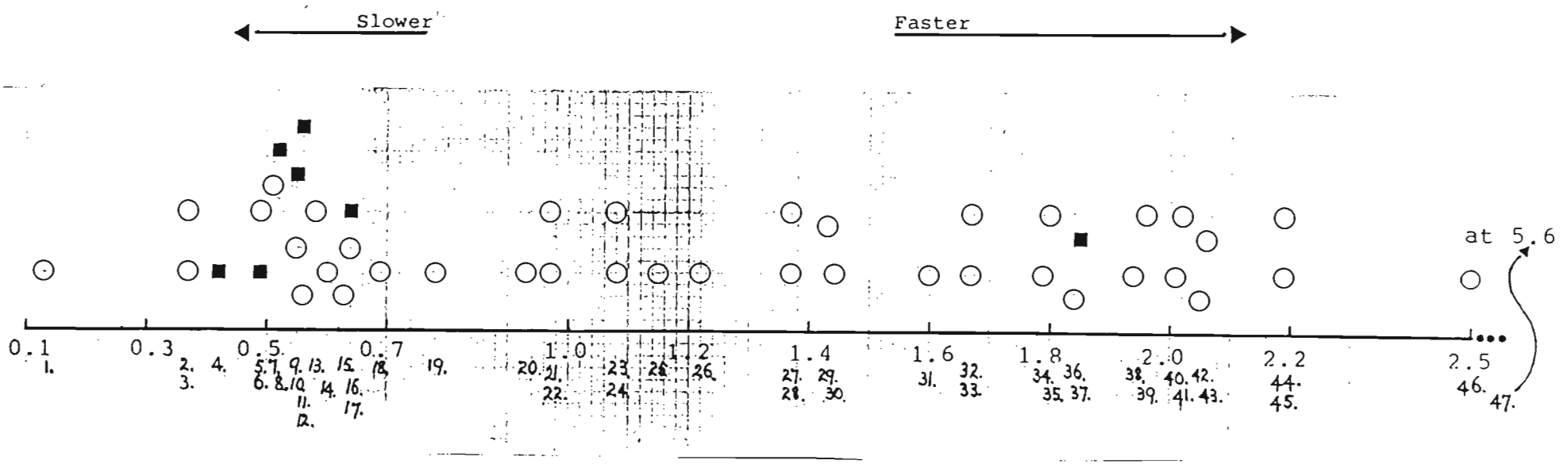
In Summary

After thirteen years of directed experimentation (since Krugman, 1970) the status of the Emery hypothesis can be judged from Figure 11.4. Here I have added in the results of other research which while not dealing directly with television, used reflected and/or radiant light conditions and presented data in an appropriate form for comparison. All conditions used are 'Eyes Open'. The tasks are briefly described in the detail below the table and are more extensively discussed in Chapter 13. Here they serve only to provide a somewhat broader context in which to appreciate the relationships between the direct studies. The map is not entirely satisfactory because of differences in the various research methods and their reporting. Wherever possible the ratio of beta to the mean of theta and delta has been used. But Krugman, Gevins et al and Legewie et al did not report delta. These ratios are therefore beta to theta. Other difficulties inhere in the varying measures taken from different locations, and

some figures have been estimated from graphs. The table does not include the work of Featherman et al (incompatible measure), Walker (did not report either theta or delta), the Weinstein team (took only one band at a time) and Rossiter and Schaffer (used pupillary responses, not EEG). Each study has however been reported upon above and discussed by its authors in terms generally supportive of the hypothesis subjected to review in this chapter.

Apart from these studies and those summarized in Figure 11.4 there are other studies such as Giannitrapani (1971) whose results are also not amenable to this form of analysis. His subjects were thirty two right handed male 11-13 years olds, comparable to Silberstein et al's sample in all but sex. They rested, looked at a poster (ambient light) both with and without diffusing goggles, among other tests. All conditions were performed lying on a bed (p 139) which could be expected to be more 'relaxing' than sitting in front of a TV screen. Firstly, we note that in contrast to Silberstein et al, Giannitrapani found highly significant differences over all conditions, frequencies and particularly brain areas; frontal, and temporal as well as occipital. Frequencies recorded ranged from 1-33. Secondly, looking at a poster as patterned reflected light and as diffuse reflected light (wearing the goggles) both produced increases in fast wave activity and decreases in the alpha and slower bands. That is, visual activity involving reflected light showed the hypothesized relativities. There was also greater beta activity in the diffuse than patterned light condition and the significance of this is discussed in Chapter 13. Giannitrapani found his results to be consistent with previous literature.

Figure 11.4. Summary Map of Relativities for Radiant and Reflected Light Perception.



Where: ■ = Radiant Light; ⊙ = Ambient Light. No's 1–47 indicate references as immediately below.

1. (L) Mental Arithmetic, Fronto-central area(F-c); 2. (L) Writing a complicated word test(F-c); 3. (G) Koh's Block Design; 4. (L) Visual tracking(F-c); 5. (L) Acoustic tracking(F-c); 6. (S) Televised Text, Occipital(0); 7. (S) Eyes Open (0); 8. (K) Watching TV(0); 9.(S) Televised Documentary(0); 10. (S) Eyes Open(0); 11. (S) Eyes Open(0); 12. (S)Projected Text; 13. (S) Eyes Open(0); 14. (S) Eyes Open(0); 15. (G) Mental paper folding; 16. (S) Televised Interview(0); 17. (S et al) Visual Reasoning(0); 18. (S et al) Eyes Open(0); 19. (L) Drawing a wavy line(temporo-occipital,t-o); 20. (S et al) Eyes Open(Temporal); 21. (S et al) Visual Reasoning(T); 22. (DW) Mental arithmetic; 23. (G) Reading; 24. (L) Mental arithmetic(t-o); 25. (S et al)Visual Reasoning(F); 26. (S et al)Eyes Open(F); 27.(DW) Silent Reading; 28. (DW) Eyes Open; 29. (L) Acoustic tracking(t-o); 30. (DW) Eyes Open; 31.(DW) Eyes Open; 32. (L) Writing complicated word test(t-o); 33. (G) Writing from memory; 34. (D) Koh's Blocks; 35. (L) Drawing wavy line(t-o); 36.(D) Etch-a-Sketch; 37. (L) Visual tracking(t-o); 38.(D) Mental arithmetic; 39.(D) Form Board; 40.(D) Tonal memory; 41.(D) Writing a letter; 41.(D) Eyes Open; 43.(D) Verbal listening; 44(D) Eyes Open; 45.(D) Mentally composing a letter; 46. (G) Scribbling; 47. (K) Reading hard copy(0)- off graph at ratio 5.6.

Where: L=Legewie et al(1969); G=Gevins et al(1979(a)); S=Silberstein et al(1983); K=Krugman(1970); S et al= Stigsby et al (1977); D=Doyle et al(1974); DW=Dolce and Waldeier(1974)

Measures: D=β:δ+θ/2; DW=β:δ+θ/2; L=β:θ; S=β:δ+θ/2; S et al =β:δ+θ/2; K=β:θ; G=β:θ (but this is a measure of no. of people

The map described as Figure 11.4 shows the range of results for both radiant and reflected light conditions. There is a distinct clustering of radiant instances at the slow end of the scale and only one case amongst the more dense concentration of reflected light conditions towards the fast end (no.37). The deviant case came from the Legewie et al (1969) study of visual tracking tasks using an oscillascope and measured over the temporo-occipital area.The same task measured over the fronto-central area (no. 5 on the graph) showed a ratio very close to the results of radiant light testing by Krugman and Silberstein et al. The difference cannot be explained solely by location as Krugman and Silberstein et al's results were from occipital leads. Task characteristics do however provide an explanation screen and closely associated with this area.

The map yields the following X2:

	Slower	Faster	
Reflected	16	24	
Radiant	6	1	X2=5.00

p <.05

This result is significant. There is really little else to say. Despite difficulties with the interpretation of theta and the anomalous case of Legewie et al, there does appear to be a radical difference in the human reaction to radiant versus reflected light. The weight of the evidence about the system state of adaptation at the perceptuomotor level shifts the odds towards television being a maladaptive medium. Content obviously plays a role; estimates vary as to

its influence. We cannot however, make an overall conclusion at this point. The range of reaction is not sufficient nor clearly differentiated to judge whether the focal condition determining adaptation has been satisfied. Fortunately, there is other evidence which permits a more sound judgement at this level of mechanism or process and we survey this in the next three chapters. Before we turn to this evidence we shall look briefly at other sets of data which concern the hypothesis under review in the sense that they preview new lines of research.

2. Other Evidence Pertaining to Light Source and Cortical Activity

A few studies have indirectly touched upon the difference between radiant and reflected light in the course of exploring other hypotheses. None constitutes a direct or clean test such as did Rossiter and Schaffer (1969) but all are instructive in adding to our knowledge of these dimensions and how their differences may be precisely measured. Others have begun to explore more macroscopic patterns of normal cortical activity over extended periods. These data extend the analysis of direct testing in different directions; both confirming that there is a phenomenon associated with viewing television which is related to its radiant light characteristic and then, to its implications for normal, everyday alert waking behaviour as seen through the perceptuomotor end of the telescope.

(i) A Difficulty with TV as Instrument

In a series of articles and notes the Van Lith team has documented the particular difficulties encountered when attempting to use TV technology in clinical work. Using TV to evoke cortical potentials instead of previous apparatus,such as Cobb & Morton's projection method and Spekreijse's mirror apparatus, they obtained results which were not in accordance with earlier studies (Bartle, et al, 1978). Testing the difference between projector and television systems with 20 normal subjects they found the amplitude of evoked potentials to be higher and latency times to be longer with projector than TV.

Table 11.12 Differences Between Projector and TV in Evoking Cortical Potentials

	Projector	TV
Amplitude	9.11uV SE. 4.08	6.9uV SE. 2.93
Latency	98.29ms SE. 8.63	94.27ms SE.16.04

As shown in Table 11.12 the difference in the standard deviation of latency times is "impressive" with that obtained with TV being almost twice as high as with projector. Their conclusion was that the "50Hz signals probably via the TV set seriously impaired the evoked potentials", (Van Lith et al, 1978, p 222).

Following up on this distortion they tested subjects who always showed much of this 50Hz noise with a blank screen, without a luminance or patterned stimulus. They found they could not reduce the 50Hz noise by electrically shielding the subjects or by using a 50Hz notch filter. However, if the subjects closed their eyes or if a black cloth was draped in front of the screen the 50Hz potentials almost entirely vanished. Their conclusion here was that these potentials are not artefacts, but responses, mediated through the visual system, which are dependent on retinal illumination. The two factors responsible for both the variable latency times and the visual hum they believed to be firstly, the sequential lighting up of the TV screen every 20 ms and secondly, the small E.P. visual field; the part of the visual field from which the evoked potentials are mediated. "Since it is caused by a characteristic of TV systems, visual hum will not be present when projector systems are used." (Van Lith, et al, 1979, p 781). Barber (1981) similarly found that the temporal luminance properties of the television system when compared with a slide projects or a photic stimulator "produced maleficent affects on the VEP" (from abstract).

For their colleagues who would wish to continue to use TV instead of projection, they suggest two ways to reduce the problem:

(1) by lowering the mean luminance of the screen, although this will depress the height of the E.P.'s and also lengthen the latency time, and

(2) by increasing the frame frequency of the TV set which will also decrease the variability in latency time.

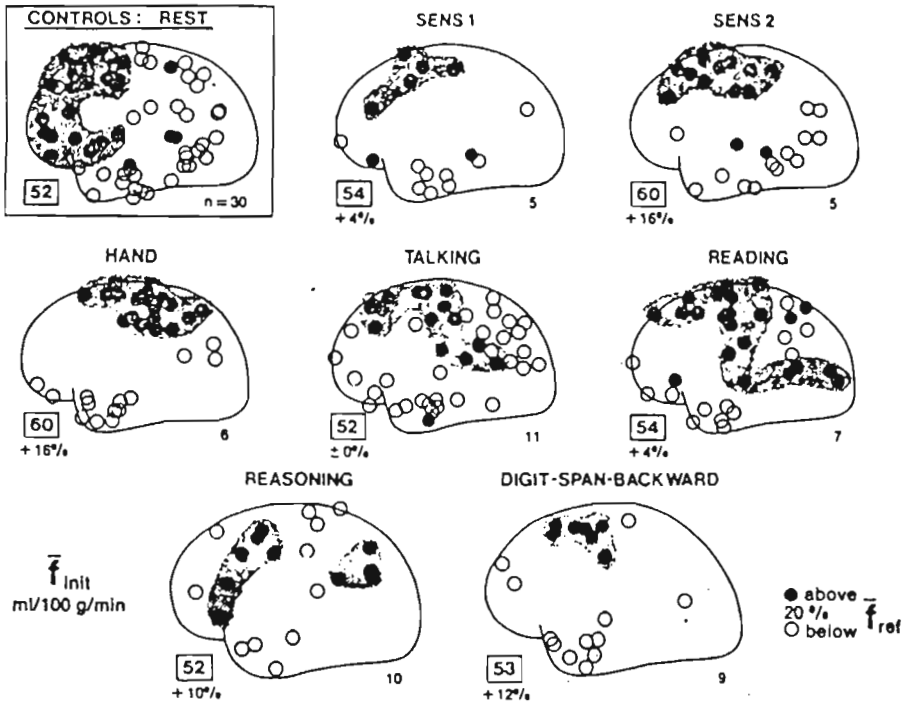
They issued a further warning about the use of TV in 1980 (Van Lith et al, 1980, abstract only).

The lessons to be drawn from this work are clear. They had no a priori reason to believe that using TV in place of projection would seriously distort their results. They were also obviously disturbed by the fact that their results via TV could be so different and wished to warn colleagues who would almost certainly move from projection to TV systems for reasons of convenience. Thirdly, they isolated the problem as a genuine C.N.S. response to the intrinsic nature of the CRT technology itself. The substantive findings of dampened amplitude and increased variability in latency times with TV correlates highly with the results of other and quite different studies. In particular, the variance in latency confirms the results of our survey of TV epilepsy (next chapter) in that it stresses the range of vulnerability to television's neurophysiological effects.

(ii) New Techniques for Brain Research

Because of the difficulties encountered by EEG researchers in relating their findings in a meaningful way to the functional anatomy of the human brain (and there is more on this below) other methods have been developed (Ingvar, 1975). These are known as Regional Cerebral Blood Flow (rCBF) technique and Positron Emission Tomography (PET). They are based on the concept of metabolic regulation of the flow such that the level of neural activation determines the rCBF or level of oxygen available, 02.a. As sophistication and experience with these techniques has developed, so they have been able to be applied to a wide

Figure 11.5 Patterns of Brain Activity shown by rCBF (taken from Ingvar 1975, p 409)



" - at rest the rCBF distribution is distinctly "hyperfrontal"
- during low and high intensity contraloreral cutaneous stimulation (sens I, sensI II) there is a precentral flow activation which increases with the stimulation intensity;
- during contralateral voluntary hand work the main flow increase takes place over the rolandic and parietal regions;
- during speech and reading a z-like acitivation pattern is induced over premotor, rolandic, and the sylvian region. During reading the lower part of the z is specially marked;
- problem solving which includes visual activity (reasoning) augments the flow over pre- and postcentral association cortex.
- if visual activity is not involved in problem solving (digit-span-backward test) only a premotor activation is seen. "

range of phenomena including the imaging of dopamine receptors implicated in Parkinson's disease and schizophrenia (Wagner et al, 1983), the relation of emotional arousal and auditory stimuli in conscious rats (Le Doux et al, 1983), and extensions from the brain to any part of the body (Singer, 1983). This is only a selection from a rash of studies exploring the potential in this new group of technologies. Their great advantage lies in their ability to produce a more accurate and precise picture of mental activity in different areas in direct relation to task than that obtained from EEG studies, which to this day remain vulnerable to speculation. Some work with these techniques has been done in the areas under examination here.

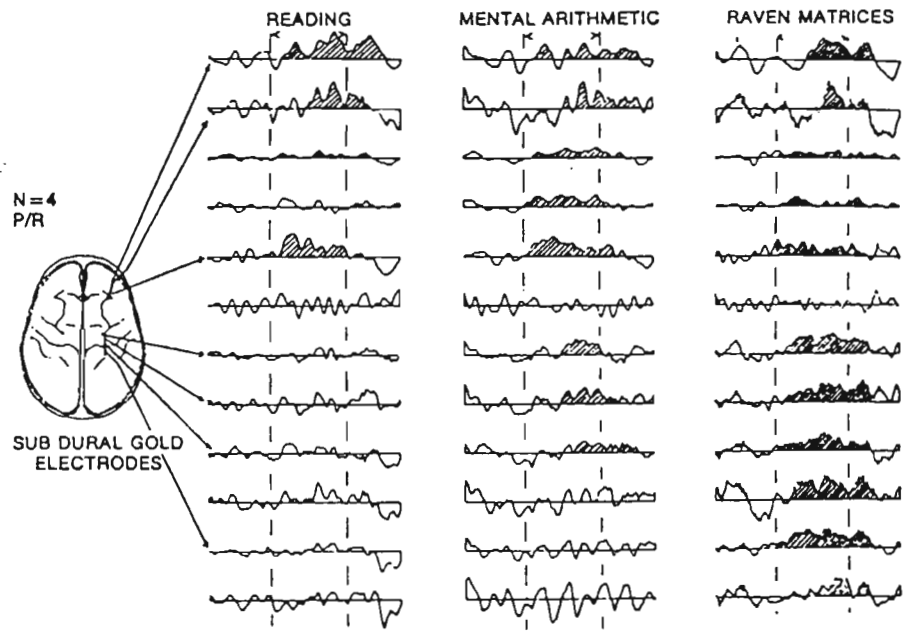
In a series of studies and replications the Ingvar team has established that there is a characteristic resting pattern and that reliable changes take place with activities. The resting pattern has marked high flows over the premotor and frontal regions which may include values of up to 30% above the hemispheric mean. Low flows are apparent over the temporal and parietal areas. This 'hyperfrontal rCB landscape' disappears in spontaneous sleep and anaesthetized subjects, as well as in various activities and in chronic schizophrenics.

Speech was investigated by asking ten S's to repeat automatically the names of the weekdays or months over and over again. S's were also asked to read aloud a simple text from a weekly magazine. Patterns obtained are illustrated in Figure 11.5. With automatic speech the flows shifted posteriorly to a "Z-like figure" including the premotor, the rolandic and the sylvian region. This contains Wernicke's area. Reading produced a similar pattern which was more pronounced over the posterior occipital parts of the hemisphere.

Figure 11.5 also illustrates the patterns obtained during problem solving of Raven's matrices and a digit-span-backward memorizing test. Both gave an increase of flow in pre-motor and frontal regions with the Ravens also activating parieto-occipital regions. Abstract thinking, memorising and problem solving especially, involve the pre- and post- central so called association cortex of the dominant hemisphere (Ingvar, 1975, p 405).

Using measures of oxygen availability (02a) Cooper and Crow (1975) found that during reading, increases in 02a were evoked in the frontal regions while mental arithmetic evoked more widespread changes. Raven Matrices produced much more widespread change, "spreading into the motor and sensory motor areas even though no motor task was demanded except the uttering of numbers indicating the choice of patern" (p 390). Figure 11.6 illustrates the extent and distribution of these fluctuations in 02a.

Figure 11.6 Changes in 02(a) During Motor and Mental Tasks (taken from Cooper and Crow, 1975, p 391)



Ingvar et al also detected individual differences and the fact that the total amount of flow increase correlated not with performance but with motivation. But the rCBF changes indicate two components, one of motivational arousal and the other of task-specific regional (structural) performance. In discussion of resting ideation Ingvar concludes:

> "In the light of these findings one may go back to Mode I, the rCBF landscape recorded in the silent laboratory in the dominant hemisphere of normal resting subjects, awake with closed eyes. This 'hyperfrontal' pattern apparently corresponds to the undirected, spontaneous, conscious mentation, the 'brain work', which we all carry out when left alone undisturbed. It appears of great interest that in this resting mode there is a relatively high activity especially in the premotor and frontal regions.
>
> Here the striking similarity between the resting mode on the one hand and the sensory modes (Fig. 2), as well as the problem solving modes (especially well seen in the non-visual task (Fig.6) on the other, should be stressed. The most important differences between the rest situation and the modes mentioned appears to consist in that the sensory and problem modes showed a) a higher contrast, i.e. greater differences between peaks and valleys in the rCBF landscape, and b) an increased flow (functional) level above the resting

level. The level was only slightly higher in Sensory I, higher during non-visual problem solving, and highest in sensory II (discomfort/pain).

This sequence: waking rest - problem solving - pain, appears to reveal for the first time a fundamental stratification of man's conscious mental activity.

It is apparent that these modes of brain activity - of consciousness - engage precentral and frontal structures especially. It then comes natural to attribute this type of frontal activation to an increased influence from the non-specific, mediothalamic, frontocortical projection system (Skinner & Lindsley 1973). This system activates the anterior parts of the brain where the 'intentions', the programs for motor and emotional behavior are synthetized in order to enable an adequate goal directed intentional behavior (Pribram & Luria 1973).

This general interpretation is indirectly supported by the fact that in deteriorated chronic schizophrenics the normal hyperfrontal rCBF pattern is lost, and so is the normal mentation including a goal directed behavior of the individual (Ingvar & Franzen 1974, cf. Ingvar, this symposium p 478)." (Ingvar 1975, p 411-2)

Clearly the sequence indicated is one of intensity of motivation or purposefulness; its proposed mechanism and also its inverse correlation with schizophrenia echo the theoretical position of Emery and Emery (1976). On the latter point there is also confirmation from McLean (1970, p 137)

Cooper et al (1966) showed that tissue oxygen available (02a) shows a rapid increase with metabolic activity which has been raised by sensory and electrical stimulation. Comparing stroboscopic illumination (radiant) with the presentation of picture and patterns (reflected) they found:

(a) Radiant vs Reflected: Presentation of pictures (reflected) caused a rapid increase of 02a of about 20% at electrodes lying in area 19. Stroboscopic illumination caused no change of 02a or blood flow at the same electrodes. Correspondingly, the EEG record showed much more de-syncronization of alpha activity during presentation of pictures than during flicker (radiant) (p 182). There was only one localized instance of change with flicker and that was in the right hemisphere (p 184).

(b) Content of Pictures: There was only a transitory effect when reflected light was presented without a picture. A simple geometrical pattern caused a large increase in 02a. A more complex picture caused a significantly bigger increase in 02a. An abstract picture showed little more effect than the simple pattern. Presentation of several pictures of the same type, in this case of mountains, lead to a diminishing change of 02a. Presentation then of a new type of picture (people) caused an immediate rise of 02a.

Clearly the contamination of medium and complexity precludes any final judgement. However, we note that while the reflected light without picture had a transitory effect on 02a, the stroboscope had none (with a small exception in one person). The comparison of content via the reflected light is as predicted by Cooper et al but meaningfulness rather than complexity may better describe the sequence of affordances presented. This can be scaled as shown in Figure 11.7.

Figure 11.7 Affordances Scaled for Meaningfulness by 02a.

Meaningfulness

Low ← → High

No Content	Geometric Patterns (not found in nature)	Abstract Picture (found only under certain conditions, e.g. Aurora, cloud formations, wave patterns etc.)	Mountains (natural but remote)	People, Faces (real, human and immediate

The content of pictures along this dimension obviously evokes different levels of cortical potential and activity. As described by Cooper et al they appear to scale according to their immediate intrinsic interest and survival value in the given ecological environment.

Phelps et al (1981) conducted a similar study using bright, white light, a 2-cycle p.s. alternating black and white checkerboard pattern (radiant) and for two of their normal group, a view of the park from the laboratory windows. The radiant white light produced only small increases in the metabolic measure (LCMRG1c) in the primary and associative visual cortex (PVC and AVC). Introduction of pattern to the radiant light caused an increase in metabolic rate which was relativel higher in the AVC, a higher order structure, than the PVC. This was consistent with the known greater involvement of the AVC with 'complex visual interpretations' and with Cooper et al's findings. "When subjects viewed the complex scene of the park, the metabolic response was the largest we observed, averaging 45% in PVC and 59% in AVC...the increases were highest in the AVC (about 10 times more than the increase from eyes-closed controls to white-light stimulation in AVC) which appears to reflect the extensive recruitment of the higher-order AVC for visual interpretations of complex visual scenes" (1981(b), p 254). They concluded that "metabolic activity of the human visual cortex increases as the complexity of the visual scene increases." (1981(b), p 527). See also Phelps et al (1981,a) for a more brief discussion. Jerome Engel (1980) commented on similar work with three conditions; eyes closed, white light and campus environment. Activity increased across the conditions as outlined.

Identical comments apply to this work as to Cooper et al's. Medium and content are confounded in their experimental designs but the scale of metabolic neural activity fits a concept of meaningfulness. Neither team conceptually anticipated any distinction between radiant light and reflected light and both employ the stimulus-response terminology

which inevitably stresses 'complexity' rather than 'meaning'. Both studies however confirm and reinforce the conclusions that:

(a) the new nuclear metabolic techniques are extremely useful in deciphering the CNS,

(b) the effects of radiant and reflected light may be distinguished by these techniques,

(c) we are adapted to extract meaningful information from our environment in a way which may be scaled in terms of its immediate biological or ecological import, and

(d) more of this meaning is extracted from ambient than from radiant light; extraction of meaning is directly related to cortical arousal.

These conclusions are absolutely contrary to those of the Gevins team, namely that differential patterns of arousal cannot be detected between forms of perceptual work. Their highly controlled EEG studies appear to have succeeded in throwing the baby out with the bath water. Obviously what is now required is a simple and direct test of the Emery hypothesis conducted with metabolic mapping.

Duffy et al (1980) have argued that any area chosen to test hypotheses should not be limited except by the constraints of the method itself. This suggests use of rCBF as, in addition, Sol et al (1978) have argued that rCBF is most useful for two reasons:

(a) that it indicates more widespread cortical involvement than other methods, and

(b) "allows the study of dysfunction as separate from actual tissue destruction" (p 632)

I would now predict a characteristic pattern reminiscent of Krugman's 'characteristic mode of response' which reflects both the lower level of arousal associated with the radiant nature of the technology and some relatively minor fluctuations due to meaningfulness of the content in the AVC. It will be clearly distinguished from the resting pattern by lower levels of flow in the hyperforontal areas and from reading, speaking etc., by lower levels of flow in these relevant areas.

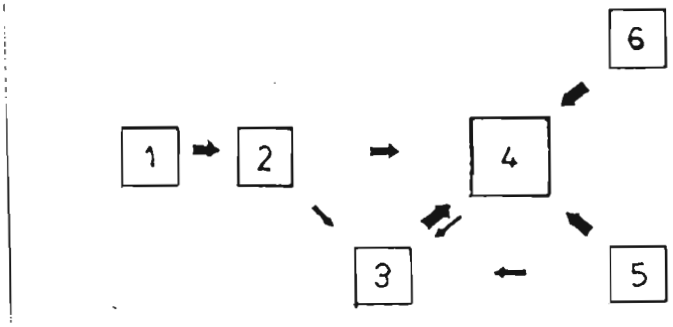
(iii) The Adaptiveness of Environmental Scanning

Finally we compare the trend of results surveyed here with the profile of a normal waking day. Simon et al (1976) took continuous recordings of six males over a 48 hour period. They found six distinct waking stages which express various activity stages within the CNS (p 55). Two in particular are relevant here; W4 and W6.

W4, waking stage 4, shows an EEG where less than 20% of the epoch is disturbed by eye movements or motor activity, an EMG record of small to medium amplitude activity, and an EOG where more than 50% of the epoch consists of rapid eye movements. It is a "state of alertness ...associated with activities such as reading, or, more generally, interaction with the environment" (p55). The largest proportion of the total time (roughly two to three times that of any other stage,

from their Figure 2, p 54) was spent in this W4 stage, and it was observed to be of "essential importance" (p 53). Its centrality can be judged from their Figure 3 reproduced here as 11.8.

Figure 11.8 Transitions between the waking stages W1 - W6 of all 6 subjects over a 12 hour period (Simon et al 1976, Figure 3)



(The thickness of the arrow is proportional to the number of subjects whose respective transitions exceeded the 33% level (p 53)).

The only transition from W4 was to W3, a more specific 'orienting' response.

Waking stage W6 appeared while looking at pictures, a stationary object and with some reading. The authors discuss it as fixation with small saccades. "Only during reading do the saccades change to reading movements" (p 55, added emphasis). This discussion certainly fits with Featherman et al's observation of the saccadic difference between watching TV and reading from TV. More generally, W6 approximates a viewing state, but in the normal waking day was of minimal importance

in terms of time. It was however, the most homogeneous state in terms of individual differences and it is entirely possible that S's were watching television during the W6 periods. Details of activities are not given in this report.* Nor do Simon et al report frequency data but they do confirm the essential adaptiveness of spending a majority of waking hours in an alert, active state of environmental scanning or vigilance, a state which watching television, as measured by empirical EEG data appears not to induce.

* In response to my query about this, Dr Simon replied that watching TV was not part of the protocol although there was sporadic viewing, and the idea seemed to her, very plausible (letter, 19.12.83)

Chapter 12 The Extreme Response to CRT's: Television Epilepsy

1. Introduction

Epilepsy has long been treated as a scourge of the human race. From ancient to more recent times it has generated a mixture of fear and reverence as must any such powerful phenomenon originating in the human brain. (See for example Dostoyevsky's The Brothers Karamazov) More recently epilepsy has yielded much of this mystique under the onslaught of scientific methods of study. Our concern in this chapter is to examine current knowledge of the relation between epilepsy and the CRT. The previous chapter shows that the question raised as to the adaptiveness of this technology is a real one, although the effects fall mainly within the normal range of neurophysiological events. It's status as a maladaptive technology cannot be confirmed without evidence of a wider range of effect. This chapter provides data on one response to the CRT that is strictly maladaptive, and thus establishes the extreme end of the scale.

From the first report of Livingston, 1952, this phenomenon of TV epilepsy followed the introduction of TV around the world with the next cases reported in Czechoslovakia and Sweden. (Klapetek, 1959, Karlsson, 1959). Klapetek explicitly questioned the wisdom of encouraging mass access to a technology with such profound physical and mental effects but, tucked away in an esoteric scientific journal, his warning went unheeded. In 1961 Lange reported on 14 cases (Lange, 1961) and by 1964 Charlton & Hoefer wrote "It was not long before TV viewing was inculpated as a precipitant of epileptic attacks." By 1975 in a comprehensive review article on photosensitive epilepsy Jeavons and Harding stated that the "commonest precipitant appears to be television" (p 11; Wilkins et al,

1980, p 111) running at about 66% of all cases (Jeavons and Harding, 1975, p 105). Given an incidence somewhat greater than 1 in 10,000 population and this likely to be an underestimate for reasons given below, we are looking at around 1,500 cases in Australia of which over a thousand are likely to be television induced. If we accept the broader definition of photosensitivity discussed by Wilkins et al (1980) we get an 'at risk' rate of 10% for adults and 15-33% for children. These figures include a variety of anomalous EEG reactions to intermittent light, not all of which are photoconvulsive. As late as 1980 there were still confusions in the literature about terminology, the specificity of effects and concepts of 'normality' (Wilkins et al, 1980, p 86). Unfortunate as this state of affairs may be, however, it does illustrate that there is a range of response to light from strictly 'normal' to strictly abnormal.

Incidence rates have also been found to vary between countries with those such as Australia which adopted the technology applicable to AC mains of 50 Hz having a higher incidence than those found in the US where 60 Hz was adopted. It is then perhaps time to look more closely at this phenomenon and reassess Klapetek's 1959 warning. In passing we may ponder the deafening silence of the medical profession at large. As I shall elaborate, while there is extensive agreement as to some of the precipitating factors in TV epilepsy it has not been possible to find an occasion in the literature on which public warning or education has been attempted. Even if this were done in the early fifties it would be unknown to most parents of young children today. This paper then may help to serve such a function as well as throwing further light upon the range of response to the CRT technology.

Both source and reaction are broadly based. Cases have been reported of the effect of a single flash of light, without stroboscopic effects (Charlton & Hoefer, 1964) and of an attack in a movie theatre. "One man had a tonic-clonic fit while at work in front of a visual display unit" (Jeavons and Harding, 1975, p 63) but he showed no abnormality and was not suffering from photosensitive epilepsy. Video games have now also been implicated. The Lancet reported on a normal 17 year old who suffered grand mal and/or auras after playing 'Astro Fighter' for 20-30 minutes. The precise trigger was the last two seconds of the game which is multicoloured and stroboscopic, flashing at about 15 Hz (Rushton, 1981). A 17 year old girl suffered rigidity, unconsciousness and some shaking of the limbs after playing 'Dark Warrior' which contains a sequence similar to 'Astro Fighter'. The EEG showed a pattern considered to be typical of photo-convulsive epilepsy and she was sensitive to light flashing at frequencies between 15 and 21 Hz. The authors of this note also criticize their fellow "doctors who are addicted to these games and deny that such a problem exists" (Daneshmend & Campbell, 1982). Two Pac-Man cases have been reported in the USA, but no details were available. (Philadelphia Inquirer, 1983)

2. Photosensitivity and Photosensitive Epilepsy

Photosensitivity and its range of effects have long been known through spontaneous occurrence. Mawdsley (1961) begins his paper with mention of the ancient Roman knowledge of seizures induced by a rotating potter's wheel, followed by early 19th and 20th century observations.

Since 1946 or perhaps 1934, (Adrian and Matthews, mentioned by Mawsdley, 1961) with the widespread use of intermittent photic stimulation (IPS) through the electronic stroboscope, abnormal discharges have been

activated in clinical and laboratory settings. IPS is simply the flashing of a radiant light source, the effects of which are a powerful diagnostic tool. It is more potent when the eyes are open rather than closed but the moment of eye closure is most potent of all eye states. (Panayiotopoulos, 1974)

In laboratory and clinical use IPS is used to determine a point along the normal/abnormal continuum of the dimensions of visually evoked cortical potentials, VECPs, or more simple, EP's. These are the brain's fundamental electrical adaptive response to visual stimuli. The behavioural pattern of these discharges in terms of such components as amplitude and latency informs the neurologist about the condition of cortical function. The characteristic epileptic form is bilateral spike and wave discharge with a slow component at 2.5-3.5 c.p.s., or polyspike and wave discharge. "Spike and wave discharges in which the slow wave component is between 4 and 7 c.p.s. (theta spike and wave) appear to be less common in patients with epilepsy and more common in those with a nonepileptic, or doubtfully epileptic condition." (Jeavons and Harding, 1975, p 23, and see also p 63)

Wilkins et al (1980, p 86) list four unusual responses to intermittent light which have little or no association with epilepsy per se. More generally, a range of system and environmental states has been found to precipitate or increase photosensitivity. These include sleep deprivation, points in circadian rhythms and hormonal fluctuations such as the menstrual cycle. In the absence of any EEG effects there is evidence of heightened photosensitivity under certain conditions. This which is discussed in greater detail below, is often described as

discomfort, annoyance or a vague sense of psychological strangeness allied to lack of vigilance or control.

Spontaneous photoconvulsive occurrences are frequently observed with sunlight being, nowadays, the most common cause after TV; moving into bright sunlight or the flickering effect produced by driving through trees on bright days. Others have been caused by discotheque stroboscopes or by helicopter rotor blades. There has been discussion within the profession of the dangers of super 8 movies. There are now many reported cases of self-induction, either by such actions as moving the hands across the eyes in bright sunlight, or by approaching or adjusting the TV set. While the wealth of literature attests to the varied range of sensitivities under differing conditions, diffuse intermittent light is most commonly used to induce a photoconvulsive response in photosensitive people. More recently, research has clustered around pattern sensitivity. "Light does not have to be intermittent to be epileptogenic." (Wilkins et al, 1980, p 90)

3. The Relation between CRT and Photosensitive Epilepsy

Binnie et al (1973) established that watching television did produce abnormal responses in patients with pronounced photoconvulsive response; discharges increased five fold during viewing and obvious flickering was not a necessary precondition. Because this result conflicted with previous studies it raised the question of what other properties are built into television which may affect such a response. They presumed these to be other minor instabilities in normal domestic sets which were not present in the higher quality equipment used by professionals. That the everyday equipment they used was a more powerful stimulus than photic stimulation was shown by one patient who returned after her

anticonvulsant therapy had been increased. She was no longer sensitive to photic stimulation but again produced paroxysmal activity whilst watching television. Jeavons and Harding are confusing on this point. They consider that photoconvulsive responses may be found in IPS which indicates photosensitivity to the massive, provocative stimulus used in the laboratory, and it is entirely possible that the individual may never encounter such a powerful stimulus in the outside world. A diagnosis of photosensitive epilepsy should only be made if the patient has had a fit induced by flickering light or pattern in his normal environment. But then again they also state clearly that diagnoses can be made only by producing EEG abnormalities during IPS. A diagnosis of photosensitive epilepsy cannot be made on behavioural evidence, e.g., taking fits whilst watching television; only by EEG abnormality induced by photic stimulation. And elsewhere they mention that it is difficult sometimes to confirm a positive diagnosis in the lab.

By 1980 Wilkins et al had decided that "a history of consistent association between attacks and television viewing, together with the finding of photosensitivity on EEG investigation is necessary to establish the diagnosis" (p 111). This is certainly rigorous as a diagnostic procedure but neglects the consequences of the fact that seizures are not consistently correlated wtih laboratory induced abnormalities. In layman's language television epilepsy is to a large extent a phenomenon of normals. (Table 12.1)

Table 12.1

The Relation between TV, Normality and Epilepsy
(from Table II. Jeavons and Harper, 1975, p 32)

Group	Fits with TV	Fits with light	Spontaneous fits	Total N	%	Remarks
A	x			160	35.2	nearly ½ have normal basic EEG's
B	x		x	99	21.8	nearly ½ have normal basic EEG's
C	x	x		21	4.6	No data given
D	x	x	x	19	4.2	17 show spontaneous spike and wave
E		x	x	33	7.3	High proportion with myoclonic ep.
F			x	122	26.9	Presumably epileptic
Total				454	100.0	

Summary Table

	N	%
Spontaneous only (F)	122	26.9
Mixed (B + D + E)	151	33.3
Flicker sensitive (A + C)	181	39.9
All Spontaneous	273	60.1
All TV sensitive	299	65.9

These tables help to illustrate the extent of the problem. They show clearly that many people may suffer an epileptic attack without any underlying abnormality and confirm Jeavons and Harding's earlier (1970) report that 56% of patients had fits only while viewing TV, and at that at least half of these had normal EEG's even when presented with light of very bright intensity.

In discussing photosensitivity as a model of epilepsy Wilkins et al (1980) state that our information about the physiology of the human visual system would be of little use "if the visual system of photosensitive patients were obviously abnormal" (p 94). Earlier case study reports (Pallis & Louis, 1961, and Mawdsley, 1961) remarked about

the absence of family history and individual abnormality in persons with TV epilepsy, who were incidentally above the normal 'paediatric' age of onset. There is also an extremely rare form of scotosensitive epilepsy where seizures are triggered by darkness and usually occur during sleep. Panayiotopoulos, 1979, has reported a case of conversion of television induced photosensitive epilepsy to such scotosensitive form.

Clearly from this initiating stimulus the phenomenon can progress.

TV epilepsy as shown by these data overturns Karbowski and Robert's (1971) objection to people with "clinically silent EEG seizure patterns", that is, patterns containing some spike potentials, being labelled 'latent epileptics'. As many normals are at risk, these individuals with 'silent' spike discharges would almost certainly be at greater risk. The issue can no longer be seen primarily as an ethical one and in fact, the incidence of television epilepsy amongst normals should, once it is widely appreciated, work in favour of breaking down the stigma attached to epilepsy as a psychological abnormality or form of madness.

The work of Beck and Bise (1983) on various forms of ionizing and Extra Low Frequency non-ionizing radiation which is reviewed in Chapter 14 leads us to believe that energy in virtually any form will alter the EEG and behaviour at certain 'psycho-active' frequencies and may trigger epileptic or convulsive responses. Of particular interest to TV research should be possible synergies arising from the action of radiant light and other energy spectra. This could account for some of the cases where routine tests for photosensitivity were negative. The research story this area is far from finished.

(i) Flicker Rate and Pattern Sensitivity in Television Induction

The question of sensitivity to flash and flicker rates has received extensive attention. As one of the critical factors in photosensitive and particularly television epilepsy the following table of frequencies (Table 2 taken from Jeavons and Harding, 1975) illustrates and helps explain varying national incidences.

Table 12.2

Sensitivity and Flash Rates Related to TV induced Fits

Flash Rates	No. Sensitive	%	
25	99	85	
30	92	79	
50	71	61	
60	25	22	
25 + 50	70	60 -	(e.g., Australia)
30 + 60	25	22	(e.g., U.S.A.)

Total No. of patients: 116

As the table shows on a population basis, the probability of sensitivity is raised by exposure to a 25 frame (50 interlaced ½ frames) per second technology rather than a 30/60 p.s. model, as these latter frequencies are above the optimum for producing photoconvulsive responses in susceptible persons. In their analysis of disturbances caused by using TV in clinical investigations van Lith et al (1979) describe precisely the action of TV light on the cortex. "The picture on a TV screen is built up by a light point which runs over the screen in 20 ms. When the light point is outside the evoked potential visual field, the screen is dark for the electrode which records the evoked potential. When the light point runs inside the EP visual field, the screen lights up in relation to the electrode placed over the visual cortex. This implies that every 20 ms. i.e., 50 times per second, the electrode over the cortex sees a light stimulus and registers an evoked potential, at least if the 50 Hz flicker is below the critical fusion frequency (CFF) of the

visually evoked cortical potentials." (p. 780) CFF is usually around the 50 Hz frequency.

But it would appear that the issue of CFF has been misunderstood. New research has shown that "single nerve cells from the optical tract of a cat can 'lock in' to the fluorescent flicker and pass signals on the brain at the 100Hz frequency". (New Scientist, 1983, p 623) Apart from the fact that there is now good reason to take seriously the discomfort caused to sensitive people by fluorescent light, there is also no good reason to assume that television flicker cannot similarly be 'locked into', at levels above CFF. That this line of research has been so slow in coming is a tribute to the power of the 'sensation' paradigm of perception. Because there was no distinction made between radiant and ambient light, and because no 'stimulus', i.e., flicker could be detected, then there could be no response to be investigated. Now there is evidence from the feline brain, this work demands replication with higher mammals.

Evidence produced by Anderson et al (1977) quoted by Featherman et al (1979, p 5) supports an extension of the cat data to humans watching television.

> "A child is increasingly likely to continue to look at the television the longer the look progresses . . . Beyond ten seconds, the child will exhibit a tendency to become 'locked in' to the screen. In our viewing room, a child typically looked at the television for only a short period of time before loowing away (54% of all looks were less than three seconds long), but if a look continued beyond about 10 seconds, we often observed the child's body relax, head slouch forward, and mouth drop open . . . Similar results were obtained when adults were tested."

This accords with popular belief about TV 'zombies' and elucidates another possible mechanism behind the view of television as endless,

purposeless but rewarding, consumatory behaviour for the total human system. (Emery & Emery, 1976, Part II) What we may in fact be consuming is the signal, the unique medium, as originally hypothesized by these authors.

Work comparing intermittent diffuse light and two types of patterned flash showed that these patterns produced spike and wave discharges in some people who were sensitive to pattern only. But because the majority of spike and wave response was occipital only, Kirstein and Nilsson (1977) concluded that "patterned light was in no case found to be more effective than diffuse light for eliciting generalized epileptic discharges." (from abstract). Depending on the properties of the pattern employed the incidence of paroxysmal EEG forms may reach as high at 70% of photosensitive patients. Wilkins et al (1980) discusses at length the currently known parameters of an optimally epileptogenic pattern; briefly one of black and white stripes of equal width and spacing with a spatial frequency between one and four cycles/degree preferably moving. All the available evidence suggest "that in photosensitive epilepsy the paroxysmal disturbance evoked by pattern is initiated in the visual cortex but that produced by intermittent light may have a less specific and less consistent locus of onset. (Wilkins et al, 1980, p 114). Wildervanck de Bl'ecourt-Devilee and Van Lith (1979, abstract only) found that measurable TV pattern-evoked cortical responses in children could be obtained only when suppressing the alpha rhythm and that mixing pattern stimuli and film proved an effective method.

Wilkins et al (1980) say that "the mechanism whereby television induces seizures is not immediately obvious" (p 111). But there is a point of

convergence between frequency and pattern sensitivity which they discuss as follows: the nature of the movement of the flying spot and

> "the pattern of interlacing lines that results is similar to a pattern of stripes 'vibrating' at 25 to 30 Hz. The lower of these frequencies is very close to that optimal for the induction of paroxysmal activity by a vibrating pattern . . . The effects of the pattern should depend not only on its temporal frequency, but also on its spatial frequency. When the patient is close to a large television screen the spatial frequency of the line pattern may be low enough (i.e., the stripes may be large enough) for paroxysmal activity to be induced. At distances where the line pattern cannot be resolved the diffuse flicker remains, due to the repetition of each field. The sensitivity of patients may therefore depend critically on the distance at which they view the set. This has been shown to be the case." (Wilkins et al 1980, p 111-2).

In a series of studies Wilkins et al (1979) isolated the relationships between sensitivities, screen size and distance from the screen. Those sensitive to 50 Hz were sensitive to TV at distances greater than [illegible] meter. Those sensitive to frequencies less than 50 Hz were sensitive to television only at close viewing range. Using three screens, small, large and masked, and a range of distances, they found that for patients sensitive at normal viewing distances, the size of the image of the screen on the retina predicted the probability of paroxysmal activity. For those sensitive only at close range, the probability of paroxysmal activity was predicted by the retinal size of the component lines. All patients were much less sensitive to the small screen than the large. However, they also found that slightly more (19:16 of their 21 patients) were sensitive to patterned rather than diffuse IPS but there was still a small but significant correlation between the two. No relationship was found between viewing distance and sensitivity to patterned IPS per se and overall patterned IPS proved more epileptogenic than the diffuse form. It is possible given the recent trend of results that pattern

rather than the single stimulus of frequency may prove a more reliable key to understanding these dynamics.

Additionally, monochrome and colour was tested in the first (1979) study but no differences achieved significance level. Laterality was not mentioned. Studies are continuing.

Whatever the result of future research in this area it should be remembered, as stressed by Wilkins et al, that the visual systems of these sensitives otherwise function normally. They are normal intact people who simply have the misfortune to be acutely sensitive to a type of stimulus (pattern or flicker) which is not found readily in nature. They cite a list of epileptogenic patterned forms in our modern urban environment such as venetian blinds and the tread on escalators. Undeniably we are creating as we did with the rush into television (Pallis and Louis, 1961) hazards for the more sensitive among us. "There are no sources of environmental visual stimulation other than the television that possess the epileptogenic properties of 50 Hz flicker and 25 Hz pattern oscillation" (Wilkins, 1978, p 1301).

The thrust of this recent research is toward a model of epilepsy as it occurs naturally in humans. "The utility of this model is that it has demonstrated how the probability of paroxysmal activity is determined by the degree of neural excitation that a stimulus induces" (Wilkins et al, 1980, p 94); in other words how the probability of paroxysmal activity represents the focal condition or goal produced by the directively correlated affordances and effectivities inherent in the given system of starting conditions. Given that for any set of environmental states there is for any given system a corresponding maximally adaptive set of

effectivities, then the epileptiform EEG is that which represents the accelerated maximization and reduction of the excitation afforded by th environment in order to restore the normal adaptive state of directive correlation between system and environment.

As mentioned above there are system states as well as environmental parameters which influence the probability of an epileptic response. This together with other data pertaining to fluctuations in the responsiveness of cortical units or specific hyperexcitabilities tends to confirm the directively correlated nature of the response. Otherwise, as Wilkins et al (1980) point out "the occurence of paroxysmal activity might be an invariable result of a stimulus above a given size." (p 108) Such a mechanical or conditioned response would bear little relation to accepted concepts of biological adaptation.

To avoid such explanations they postulate a two-stage hypothesis of photoconvulsive generation where both stages do involve the notion of critical level of excitation but where the first is considered physiologically normal and the second, that of spread of excitation, is considered abnormal. Evidence and discussion presented by Wilkins et al (1980) support an open systems perspective. As they conclude, the new hypothesis can also account for the effects of intermittent light whose characteristics suggest a binocular mechanism which is not dependent on single cortical units. Using the empirical evidence in favour of a critical mass of excitation in an equipotential context, they interpret the phenomenon of epilepsy to be "a failure of inhibitory mechanisms which is insufficient to disturb function under normal conditions o excitation" (p 114). This approach goes beyond hypothesizing about the

nature of the trigger mechanism (e.g., Muller et al, 1980, abstract only).

From this and previous research it is clear that there cannot be a single factor theory of photosensitivity. The range of cases illustrated that any one or a combination of radiant light source, flicker frequency or certain patterned stimuli can be responsible. It becomes immediately apparent that television is often, and most usually, an excellent, integrated source of all three - a highly provocative stimulus.

(ii) The 'Kindling' Model

The model of epilepsy suggested by the recent cat research is that of "kindling", as in lighting a fire. The term coined by Goddard in 1967 referred to his observation that "daily electrical stimulation of certain sub-cortical areas of the rat brain will eventually cause convulsions even though the intensity of stimulation is relatively low and initially has no such effect." (Goddard, 1967, p 1020) Interestingly enough, his rats also showed a wide range of sensitivity to this stimulation. Once the response had occurred it could be reliably elicited; but no spontaneous episodes were observed. Goddard argued that the process is analogous to learning, that is "a relatively permanent change in behaviour that depends on repeated experience." (p 1021) He issued a warning to those working with chronic and repeated brain stimulation.

His work sparked a new wave of research which was reviewed by McNamara et al in 1980. Kindling has been confirmed as a powerful model of epileptogenesis and neuronal plasticity. The stimulus can include a variety of pharmacologic agents and even electroconvulsive shock (McNamara et al, p 144) and current research is centred on the role and

patterning of neurotransmitters. As these authors point out, kindling is an excellent model because it can explain a range of human phenomena including partial seizures and minor convulsive activity as well as grand mal, although many precise relationships remain speculative. Certainly it explains why TV epilepsy may not appear until late in childhood when the stimulus has remained unchanged for years. It also accounts for the fact that repeated video game-playing is required before some people exhibit epileptic reactions.

The wide range of stimuli now implicated in kindling effects, helps also to explain the incidence of TV epilepsy amongst those who appear insensitive to radiant light, with or without pattering, and strengthens the argument that virtually any energy form can serve as trigger. For those sensitive to whatever band of energy spectra or chemical agent, the repetition of the application at low levels certainly does provide 'an excellent model' for TV epilepsy, encompassing the strength or intensity of the reaction. This has applications particularly in the case of sensitivity to patterned light which may be distinguished from single intermittent flash along the dimension of complexity.

There is as well, little evidence of any adaptation, which is consistent with the kindling model. Wilkins et al (1980) discusses the <u>possibility</u> that people may be able to adapt to the frequency of television in a manner similar to their adaptation to the direction of the scan. This follows Corbett and White (1976) who tested scans across all right and left and top and bottom combinations of movement and found significant differences on a scale from imperceptible to very annoying. That bottom to top direction, which is the opposite of the convention, was most annoying has been interpreted to mean that we may adapt to such

fundamental affordances as flicker frequencies. There are however two possible misconceptions in this argument. First, it would appear that tracking such an image vertically is from the dearth of literature, neurologically less critical than frequency of light which may correspond to psycho-active frequencies (Chapter 14). Second, the argument that visitors from 60 Hz countries to 50 Hz countries tend to express greater annoyance about the perceptibility of flicker, means only that the inhabitants of the 50 Hz countries have long since given up complaining. It does not mean in any neurological sense that they have adapted. Continued difference in incidence rates would bear this out. (Table 12.2) This is part and parcel of this thesis: television is not merely a subliminal, deceptive and seductive stimulus; for those who are sensitive to any of its properties and 'lock in', it approximates an environment.

Johnson (1963) concluded: "Research and clinical findings indicate that while the abnormal EEG response to flicker may not appear on each examination, adaptation to flicker does not occur." (p. 309) (Emphasis is mine). Early case study reports document an inability to change the individual band of sensitivity.

4. Self Induction by Television

Self-induction by any means has long been considered rare. Darby et al (1980) review instances due to hyperventilation and other means but the overwhelming majority employ visual stimulation. Since Jeavons and Harding's survey, more cases of deliberate TV induction have been reported and there is reason to believe that the actual incidence is underreported.

During studies of pattern sensitivity, Darby et al (1980) discovered that 7 out of 22 patients appeared to elicit paroxysmal activity by partial complete eyeclosure of 1 to 2 secs duration, often with marked upward deviation of the eyes.

> "The movement gave a characteristic oculographic artifact that was of surprisingly constant wave-form both within and between subjects. Sometimes the main eye closure was preceded fairly consistently by a blink, in which the eye was not fully covered by the lid ... some subjects grimaced, bit the lower lip, smiled vacantly, or touched the face with one hand during the eye closure. The incidence of discharges following the movement was generally reduced or abolished in dim lighting or darkness." (p 36)

It now appears quite clear that the movement which induces the attack is not a part of the seizure per se but a purposeful causal act. (Darby et al, 1980). It is a slow movement, quite distinguishable from blinking or closing eyes on command from the clinicians. The actual mechanism may be related to alpha augmentation which may help explain the affective pleasurable aspect.

Binnie et al's confirmatory study (1980) isolated 13 (27%) self-inducers out of a selected sample of 48 photosensitives. Using video-recording of viewing under nearly normal conditions they verified the nature of the phenomenon which in 11/13 cases resulted in an absence.

That this incidence, with in particular its inductive method of eye-closing, should have remained underestimated and unsuspected for so long, is surprising. As noted above, Panayiotopoulos showed that eye closing was the most powerful stimulus state in 1974. Given human ingenuity it would seem inevitable that such a simple mechanism should be exploited. But as we see below, subtle symptoms are often not noti[illegible] and even the more blatant such as hand waving are sometimes not

acknowledged. These studies have profound implications not only for the incidence of self-induction but for the incidence of television epilepsy more generally.

Case evidence about the nature of the experience derived from self-induction is variable but some points are clear. Mental retardation has been ruled out as a factor. (Binnie et al, 1980) Self inducers appear to be involved in a range of psychosocial pathologies, which is probably not surprising. Anderman's 1971 patient was highly intelligent, well aware of the effect on her and demonstrated that she had learned from experience how to produce it. She in fact used it to manipulate her family. Anxiety and distress are clearly implicated in the phenomenon. Goddard's original hypothesis that kindling is a learning phenomenon is borne out by the cases of self induction.

Patients are generally reluctant to discuss their feelings but when pushed, refer to vague magnetic attractions, being hypnotized. Twenty percent of those who do not deliberately induce feel drawn towards it before the seizure (Panayiotopoulos, 1979). Jeavons and Harding found that only 7% were impulsively attracted (p 105) and were predominantly males which is a reversal of the more general demographic trend for photosensitive epilepsy: girls in general are more at risk than boys in the ration of 3:2 (Wilkins et al, 1980).

Important factors appear to be distance of the viewer from the screen, stability and intensity of the picture, contrast in brightness between light of screen and room, and sharpness of the picture. This last variable is related to flicker frequency (Anderman, 1971). Those who self-induce appeared to Jeavons and Harding (1975) to have a wider range

of sensitivities but recent work has invalidated this finding. It would appear that as long as a sensitivity exists it provides a potential for purposes served by self-induction.

Becoming worried about children watching TV from too close a distance Ming'-Sheng Wang has now patented a device which monitors the distance of the viewer from the screen and issues a warning. At the same time, a motor begins to produce interference with the picture. Should this fail to deter the young viewer, the relay machine will disconnect the aerial and finally, will switch off the mains supply (New Scientist, "Keep your distance", 1983).

In two recent reports (Darby et al, 1980; Binnie et al, 1980) the importance of reducing illumination as a method of control is stressed. This affects traditional therapeutics (see below) although it was recommended by Karlsson in 1959. In early reports of self-induction it appeared to originate after spontaneous seizures have disappeared, usually following medication. This was a factor in suspecting that self-induction carries intrinsic if sometimes subtle rewards. Direct evidence was obtained by Darby et al, from a seven year old girl

> "Do you know anything about the attacks?"
> "Only if I do it hard."
> "Is it a nice feeling?" She nods and giggles, "Yes."
> "What do you feel?" She points to her head.
> "Is it nice."
> "It is not as nice as eating pudding, but it is as nice as being cuddled." (1980, p 39)

Others "described a pleasurable sensation or a compulsion to make the movement" (p 40). Self-induction implies some perceptual or affect change. Both 1980 studies emphasize that in all cases, self-induction had not been previously suspected.

5. The Question of Incidence. This has traditionally been a puzzle because as early as 1961 Pallis and Louis discussed the fact that although "some cases of television epilepsy may go unrecognized . . . the number recorded is clearly less than might be expected" (p 189). The most frequent type of fit induced by television is claimed by Jeavons and Harding (1975) to be the tonic-clonic seizure, known through the ages as 'grand mal'. It has been reported to occur in ages 5to 52 years with a case reported in a brain damaged child of 2 years and 3 months. However, TV epilepsy is known primarily as a 'paediatric' disease whose occurence is rare after 14 or 15 years and whose peak onset is around 8-14 years. Its incidence however is likely to be underestimated by neurologists because of the complicating factor of 'petit mal' or 'absence epilepsy', a very mild form indicated by total non-responsiveness. During IPS in clinical or laboratory settings, petit mal is in fact the most commonly observed form. Such brief 'absences' may well occur unnoticed during TV viewing and if there is no progression to a grand mal seizure, will never be reported. Indeed the current wisdom about the boob tube that turns you into a zombie, the truth of which may be validated by this analysis, is also militating against a more serious appraisal of its symptomatic abnormality. As Wilkins (1978) adds (and see Chapters 6 and 10) "the lack of social interaction during television viewing may mean that many seizures of the absence type pass unnoticed" (p 1301). Clinical studies have found three factors which will cause progression from the more common 'absence' to the generalized tonic-clonic seizure: a long period of stimulation, use of a trigger or double flash, or extending the photic stimulation after the appearance of EEG abnormality as in petit mal.

Bickford and Klass (1962) found that of their ten patients, four "had not been aware of seizures initiated by television, although they did have

seizures at other times. Nevertheless, the occurrence of petit mal seizures in these patients could be demonstrated clearly while th viewed the effective patterns via the television monitor, and it appeared that they did not recognize their petit mal attacks. One patient showed spike and wave discharge related to pattern stimulation, but only with minimal behavioural change (p 177), (my emphasis). "Under the experimental conditions in the laboratory, the predominant seizure induced was of the petit mal type. The manifestations of the brief attacks varied. In some patients there was arrest of movement, staring, gross unresponsiveness, and lack of recall. In others, unresponsiveness was accompanied by myoclonus. At times there were only minimal changes in responsiveness (detected by response-time measures) without other behavioural alteration" (p 77-78). It would be difficult to argue that it was the experimental environment rather than the television which induced these episodes of petit mal particularly when 6/10 had experienced TV induced seizures at home, only three of which were grand mal.

Anderman similarly reports a case where absence seizures occurred about three times a day, and often, but not always, when she was watching TV. In the 6 months prior to presentation she had only 6 generalized seizures, all of which occurred while viewing. Later during self-induction, the attacks were absence variety some of which progressed to a generalized tonic-clonic seizure. In this discussion (1962) Anderman claims that most self-inductions are absence attacks or confusional states, with or without myoclonic jerking, although "sometimes there is no visible alteration in behaviour" (p 273). T fact that parents, sufficiently observant to note their daughter's absence attacks, took 6 months to present her for treatment, even though

she had also taken six major fits, is of course another reason why reported incidence can be considered too low. Stigmas attached to "epileptic" are still powerful and apparently some parents simply wait in the hope that it will go away. For the lucky ones this hope may be justified as there is some evidence that sensitivity decreases with maturity (Jeavons & Harding, 1975) as the proportion of slow wave activity diminishes over time. But the kindling model would suggest that once a major convulsive response has occured it will be repeated on reappearance of the stimulus.

Other complicating factors arise from the fact that TV induced epilepsy may be a pleasurable or tension releasing experience which leads patients to deny its origins for fear of being deprived (Charlton and Hoefer, 1964) and seriously interferes with ameliorative medication and other forms of treatment. Certainly for the self-induced cases this presents a difficult problem. Should the pattern be in any way similar for brief 'absence' phenemona, the child will not report if there is any suspicion of deprivation. Clement et al (1976) present evidence to this effect with a study of two young women who self-precipitated attacks when spontaneous attacks no longer occurred. "The seizures consisted of absence or generalized tonic clonic attacks. (The latter are almost never encountered in 'hand waving', the most common form of self-induction reported in literature.)" As we have seen, self-induced epilepsy has now been known for over 40 years and as Clement et al make clear the major form of resulting seizure before the advent of television was 'absence'. Both these patients were reluctant to discuss the circumstances under which self-induction occurred, their feelings or their fantasy life in relation to the seizures. Similarly, they had difficulty in accepting psychotherapy and medication. While Clement

et al concluded that their feelings were more of tension relief than pleasure and could find little evidence that they were performing similarly to Olds' rats, they acknowledged that some form of reinforcement was present, either primary or secondary.

Wilkins et al, (1980) however, have returned to the position that self-induced seizures do produce a pleasurable sensation and hypothesize a direct link to the behaviour of Olds' (1958) rats. They see as partial evidence for this the fact that antidopaminergic (antiserotonergic) drugs are effective depsite the convulsant properties of some. It is therefore entirely possible that minor absence seizures do occur much more frequently with television than has been reported in the neurological literature and that there are personal advantages in concealing their occurrence. It should also be noted here that Clement et al describ their two patients as suffering from narcissistic character disorders and very low self-esteem. Low self-esteem has frequently been found in other bodies of literature to correlate with heavy viewing which strengthens the probability (long period of stimulation) that 'at risk' children are deriving benefits from petit mal incidents, unnoticed or accepted as part of the 'vidiot' syndrome. Self-esteem is also part of a wider personality influence which has been discussed above.

But there may be other contributing factors to the incidence of television epilepsy which are best discussed in the context of the more 'normal' response to the television technology. Before approaching these it makes sense to conclude discussion of the strictly abnormal response by mentioning ameliorative action.

6. Treatment

While some photosensitive patients show spontaneous reduction in sensitivity range over time it is usual for the condition to continue for at least ten years; until they are aged twenty plus years. Treatment varies depending on the clinical evaluation of the individual case. It consists of two basic elements, anticonvulsant drug therapy and avoidance of the stimulus.

Anticonvulsant drugs, with the exception of sodium valproate (Jeavons and Harding, 1975, p 95-96) are usually not prescribed for patients withoug evidence of underlying abnormality. Jeavons and Harding argue that sodium valproate, however, is useful in such cases and this appears to be generally agreed. Recent results indicate that it has a short biological half-life and rapidly passes the blood-brain barrier. Its suppressant effects are seen several hours after peak serum concentrations. Sensitivity returns after several months. (Wilkins et al, 1980, p 114).

Avoidance therapy may involve wearing polarized spectacles which remove the reflected flicker produced by sunlight on water and snow for example (see no. 6 below). But most instructions given are for more adequate control of television. The following list is taken from Jeavons and Harding (1975).

> "Precautions to be taken by patients who are sensitive to flickering lights. If these instructions are followed carefully and exactly, a fit may be avoided while watching television.
>
> 1. The patient should always view the television in a well lit room from a distance of 8 feet or more.
>
> 2. A small illuminated table lamp should be placed on top of the televsion set.

3. The patient should never be allowed to approach the television to adjust or switch channels of the set.

4. If for some reason the patient has to go near the television, then he/she should cover one eye with the palm of the hand so as not to allow any light to enter the eyes.

5. The patient should never attend discotheques or any other places where flashing lights are used, but if any flashing lights come on without warning, he/she should immediately cover one eye with the palm of the hand.

6. The wearing of polarized sunglasses out of doors on sunny days is of assistance in removing flickering reflections (from water, etc.). Ordinary tinted spectacles are of no value in this condition" (p 96).

Wilkins et al (1980) suggests in addition that patients change their set for one with a smaller screen. Failing all this they suggest placing a sheet of polarized glass over the screen and the wearing of spectacles, one lens of which is polarized at an angle orthogonal to that of the sheet. (Thereby preventing binocular viewing.) On the basis of new work they also query the value of Jeavons and Harding's advice about placing a lamp on the TV. Increasing the ambient illumination may actually serve to increase the chances of a seizure. (See also Van Egmond et al, 1980.)

Another suggestion which can be drawn from the literature is for parents to ensure that the set is in proper working order to avoid additional provocation caused by defective controls. Another, of course, is for parents to educate their children to use television as they would 'junk food'. It is not recommended that it becomes a staple diet.

However, given the age of onset of some cases in the literature it is not only children who are at risk. It is unfortunate that the following statement made by one of the foremost teams addressing this problem has received little (if any) public scrutiny. It is already undoubtedly prophetic (Chapter 14).

> "In conclusion it is worth pointing out that electronic information retrieval systems (e.g. Oracle, Viewdata) will shortly be provided as public services in several countries. With the advent of these systems and of domestic computers, the television will find a new role as an interactive visual display terminal. Whereas conventional visual displays often have slow phosphors that reduce the depth of modulation of the flicker, and they do not typically use a system of line interlace, the domestic television does not possess these advantages. If the latter is used as an interactive device, operators may be required by the positioning of controls or the nature of text to sit closer than they otherwise would to a display which in many cases is large enough to occupy most of the visual field. Given these considerations it seems inevitable that the incidence of television epilepsy will increase." (Wilkins et al, 1979, p 170).

In Summary

While the previous chapter confirmed doubts about the adaptibility of CRT technology by examining a range of data concerning the essentially normal responses to radiant and reflected light, this chapter has illustrated the fact that this technology does produce strictly maladaptive consequences for some people, at this level of psychomotor coordination. Clearly the human CNS may be sensitive (hypersensitive) to a wide range of environmental events, one of which is the operation of a radiant light source in all its forms. Repetitive single flash or patterned stimuli are effective in producing epileptogenic responses in different cases. Those persons particularly sensitive to flicker will respond with an epileptiform response even to reflected light. But the data implicates radiant light and particularly television as a more powerful and ubiquitous provocateur of epilepsy than the age-old effects of moving through a sunlit environment.

Kindling as the most explanatory and parsimonious model in the literature makes sense of the late paediatric onset of TV epilepsy; its delayed effect in general and the phenomenon of self induction. In the absence of underlying neurological abnormality a directed and specific external

stimulus is necessary and self induction serves this purpose. There are loud echoes from Emery and Emery (1976) throughout this chapter, namely habituation is a learning process; there are individual differences in sensitivity to the effects of habituation; there are abnormal effects; there are rewards to be gained and; these effects will be noted at the level of the total system. The role of neurotransmitters was foreshadowed in that report and has been confirmed by kindling studies. It is to be hoped that the kindling model will be further pursued, particularly in the context of TV epilepsy, and that long term studies will be conducted. Given the range of sensitivities, Featherman et al's (1979) test of pre- and post-television generations was simply not sufficiently sensitive to test long term effects. Results here can come only from studying individual changes over time.

The remaining task in this part III is to explore any intermediate stages of reaction between normal and maladaptive at the psychomotor coordination level which will yield the scale necessary for a strict definition of maladaptivity.

Chapter 13 Other Levels of Reaction: Theta Wave Activity and the Case for Maladaptivity.

We deal here with evidence that helps complete the picture emerging from the chapters on direct testing of TV's neurophysiological effects and television epilepsy. The questions specifically addressed involve the range of reaction to radiant light, particularly those reactions intermediate to normal and epileptic and their possible interpretations. Establishing this range establishes the case for maladaptivity and essentially completes the argument.

1. The "Mildly Abnormal" Response

Let us begin by recalling Jeavons and Hardings' finding, after surveying photosensitivity in 1975, that "Spike and wave discharges occurred equally in all groups (i.e., both normals and abnormals) but those at 3c.sec were commoner in patients with abnormal basic records, while theta spike and wave discharges (4-7c.p.s.) were commoner in those with normal basic records and fewer of these patients had photosensitive epilepsy." (p 63) Sterman (1977) found significantly greater amounts of theta activity during stage 2 sleep in epileptics than normals confirming that theta is implicated in the symptomatology of epilepsy.

In their chapter 6 entitled 'Laboratory Studies', Jeavons and Harding divided their patients into three groups.

(a) with normal records

(b) with non-specific abnormality defined as uni- or bi- lateral slow waves or other mild abnormalities

(c) with abnormal records including spikes, and spikes and wave discharges.

Unfortunately for this paper, Jeavons and Harding followed the normal neurological convention of regarding only records with spike and wave as strictly abnormal and for their purposes lumped their two first categories together. It is unfortunate in the sense that it fails to throw further light upon the hypothesis that television causes a reduction in fast wave activity which is replaced by slow (4-7 c.p.s.) activity in normals. However, they do provide some clues which are confirmed by other studies. On p 31 for example, they discuss the fact that a patient having an epileptic fit whilst watching television does not mean that patient is photosensitive. They state that TV is likely to induce drowsiness and drowsiness is certainly a more common precipitant of fits than flickering light. This would explain amongst other things why so many normals do take epileptic fits in front of the TV. Melton, et al (1967) found their results to be "in general agreement with those in the literature that the primary response to photic stimulation by normal subjects is drowsiness." (p 634) Wilkins et al (1980) note in the context of the difference between eyes open and closed, that eyes closed condition increased the lower frequencies. (p89)

By 1975 there was increasing interest in abnormal theta rhythms in children, defined by Taistra (1975) as those which are not, or only incompletely blocked by eyes opening. They usually show a pronounced parietal accentuation but can also appear synchronously over all brain regions. They are more often found in boys than girls and can be found in up to 15% of brain healthy children as well as especially found in children suffering from seizures. This abnormal theta rhythm has therefore been interpreted as a bioelectrical symptom of an <u>increas</u> <u>susceptibility</u> to convulsions of the so called centrencephalic type. (Also known as common generalized epilepsy). Palmer et al (1976) discuss

frontal midline theta rhythm similarly, not as as abnormality per se but as a pattern of clinical interest; ie 'mildly abnormal'.

At least two groups of researchers have concluded that the epileptiform discharge seen in photosensitive and pattern incidences is a "manifestation of the failure of the visual cortex to react to a massive stimulus in a normal physiological manner" (Jeavons and Harding); "the result of a failure of inhibitory mechanisms which is insufficient to disturb function under normal conditions of excitation." (Wilkins et al, 1980, p 114). In other words, the "drowsy" condition induced by watching television not only signals the failure of the inibitory mechanism in normals but is a condition for its failure. Bennett, (1963) reported on the cases of four young flyers who took grand mal seizures following sleep deprivation. His conclusion was that the centrencephalic system is vulnerable to such deprivation and that normals under such condition will exhibit 'low convulsive threshold.' This has been confirmed (Wilkins et al 1980.)

In another early study by Johnson, (1963) 102 helicopter pilots were subjected to an extensive investigation following worries about flicker in flight and the possibility of accidents following a near miss. 25 of these pilots had reported problems with flicker in flight but on testing, only two showed any abnormality in EEG records. In response to photic stimulation over 19 flicker frequences not a single abnormal record was obtained. Most pilots showed photic driving which refers to the condition of the EEG frequency following the frequency of the flicker, but this phenomenon is almost universal and is not considered to be of clinical significance. Subjective sensations were also recorded during flicker and these included perception of colors, designs and various

lights. Sixteen or 15.6% reported feeling tension, apprehension, not being able to think, disorientation, a hypnotic effect or just be bothered.

When exposed to this repetitive flicker 22 (21.5%) "became drowsy or went into light sleep; sleep activity indicated by the presence of EEG slowing, 4-7 c.p.s. of moderate voltage or activity of 2-4 c.p.s. with some sleep spindles. No 2-4 c.p.s. high voltage waves indicative of deep sleep were seen... thus for 21.5% of this sample the degree of alertness changed markedly during flicker." (p 309) Of the 22 who went to sleep 50% were unaware that they were going to sleep. Those who did realize it could not prevent it. The EEG clearly reflected a state of lowered vigilance, a condition of which 11 were unaware. Johnson discussed the implication of flicker being a source of annoyance to roughly one third of all experienced pilots and related it directly to fatigue; that which he had created for a fifth of his sample simply by exposing them to flicker. In the two other experiments, 30% and 60% of normal young men reported drowsiness during two types of photic stimulation. (Melton et al, 1967)

There are several points to pick up here apart from the continued finding that many normals respond to flicker phenomena by moving into a pattern of activity in which 4-7 c.p.s. is highly visible and a significant component of all cortical activity. The first involves Johnson's surprise that not a single man in his sample showed extreme photic activation. His reading of the literature revealed that usually in non-clinical samples (i.e., normal people) some 5% show some such extr photic activation. His explanation was that the rigour of the physical and mental pre-testing for this job ensured that the final pilot intake

was amongst the fittest and most adaptive sample that could have been found anywhere. And they were all males. Jeavons and Harding after concluding that females were more at risk from photosensitivity than males postulated the probability of a genetic factor in such vulnerability. But if Johnson's highly selected healthy sample still managed to contain near on 22% who could not resist the temptations of flicker, then we must expect that the ordinary, unselected incidence for a national population would be much higher. This is the first issue of personal or genetic susceptibility.

The second requires a survey of just what theta or slow wave (4-7 c.p.s.) activity meant for normal adults; its psychological and neurophysiological significance. We can then relate this to watching television. There is a logical priority to this question so we deal with it first.

2. Theta Wave Activity (4-7 c.p.s.)

Work on slow wave activity began early on in the history of EEG studies. There was originally little controversy about its meaning. A complexity has subsequently developed in the area of cortical theta. (There is continuing research on theta measured from the hippocampus, which is extremely difficult to observe (Schacter, 1977) but that is outside our concern here which relates to cortical activity only.) Two statements over 20 years apart illustrate one stable element in our understanding of theta activity. The first comes from Grey Walters 1953, the second from the currently required textbook for the University of Pennsylvania (Bennett, 1977).

> "Apart from the lowest frequencies in the juvenile spectrum, probably associated with the earliest and most vulnerable

> stages of cortical development, the most arresting feature in the analysis of children's records is the activity at frequencies between 4 and 7 cycles per second. These rhythms were still regarded as merely transitional between the very slow rhythms of the infant and the faster alpha activity of the adult when chance observation of the subject's change of mood directed our attention to the possibility of a more significant psychological correlation. With further observation, the following points among others were noted. Theta activity is usually dominant in records of the 2-5 years age-groups; it is approximately equal to alpha activity at 5-6 years; it is smaller above 6 years, and very small or intermittent at 10. With other technical observations, a case was thus made for regarding this group of rhythms as specific; they were named "theta" because they were first identified in clinical studies as arising in or near the thalamus, the antique bridal chamber of the brain, considered by some as the factory of feeling, the seat of emotional display." (Walter, 1953, p 203, emphasis added)

Walter observed that Theta was not associated with changes in visual stimulation but with pleasure and pain. In adults, he noted the drowsy 'floating' state signalled by a reduction in alpha rhythms and appearance of theta; a weakening of the significance of sensory information.

> "It is not the direct transmission of the nerve impulses to the projection areas that is inhibited, but rather their dissemination -- the first two operations of learning -- that is attenuated. The reader's eyes can follow the lines of print but the meaning of the words escapes him and, merging into private fancy, his bedtime story becomes a dream" (Walter, 1953, pp 239-240).

Walter also outlined the relation of theta to organic disease and brain injury.

> "Slow components are prominent, too, in epileptics betwen seizures and during attacks when there are no convulsions but only loss of consciousness. All these conditions have in common the need for protecting the brain from the consequences of its own complexity. The serious results of loss of control and protection are seen when an epileptic has a major convulsion. Then, very rapid electrical discharges predominate, and the whole system is thrown into revolutionary chaos. Toward the end of the seizure, slow waves again appear and the rapid convulsive discharges emerge only in the troughs of the slow waves. Such considerations have suggested a phylactic, or protective, hypothesis to account for the slow electrical rhythms, according to which these rhythms are the wardens of brain function, limiting the

consequences of excessive or ill-coordinated activity."
(Walters, 1953, p 246, my emphasis)

This is still the current wisdom in some circles as Bennett 1977 simply summarizes: "Theta waves have frequencies in the range of 4 - 7 Hz. Theta waves of cortical origin are mainly observed in the temporal and parietal regions of children, but they can sometimes be observed during emotional stress in adults, particularly if the stress is produced by disappointment or frustration." (p 63) The implication in the brevity of the statement appears clear; cortical theta is no longer of any pathfinding significance. In distinction, Bennett presents over ten pages of discussion about hippocampal theta and its possible roles.

This original theorizing led to some ostensible dead ends. The early studies reported by Walter 1953 linked theta in the teens and adulthood with aggressive psychopathology: "theta rhythms are scarcely visible in good-tempered adults, but they may be evoked even in them by a really disagreeable stimulus" (Walter, 1953, p 206). Results in laboratories suggested "that the withdrawal of a mildly pleasant sensation was more upsetting than the administration of mildly unpleasant ones" (p 207). Walter's conclusion was that theta is scanning for pleasure as alpha is scanning for pattern. The powerful implications of these early observations for the treatment of delinquents and society at large led to more and better controlled experimentation. In 1966 Wiener et al reported a highly controlled comparative study of delinquent and non-delinquent adolescents. No differences in visibility of theta or the slower delta wave activity were found. But the study confirmed that theta activity declines with aging. Other more recent studies reviewed by Schacter (1977, p 73) failed to find a significant correlation between theta and psychopathy.

The critical features of theta according to this early view were:

(i) a phenomenon of childhood decreasing over time

(ii) a response to 'emotional' rather than 'cognitive' stimuli

(ii) a lowered state of vigilance; drowsiness or ealy sleep stage with consequently reduced meaning of the external environment.

Feature (iii) would form a neurophysiological substrate for the concept of 'knowledge of'; familiarity rather than active understanding, with reduced ability to recall.

Work on theta continued with more sophisticated equipment and better controlled observations. Some studies tended to confirm a relation between affectivity and theta but it rapidly lost its reputation as as a simple phenomenon.

In 1971 Maulsby described the theta response in infants as "the most striking EEG correlate of affectivity" (p 157) with important implications for the study of emotional development, both normal and pathological. His case report of a 9 month old girl showed that theta was present during the onset of sleep and could be elicited in the alert state by stimuli such as kissing and tickling. Withdrawal of the pleasant stimulus caused abrupt disappearance of theta. Frustration did not induce theta activity, contrary to Walter. The theta observed during pleasure was slower (4 c.p.s.) than that during drowsiness (5-6 c.p.s.). He notes other instances of theta recorded while children were in a state of "serene pleasure and staring at favourite toys without other distractions" (p 162). (Emphasis is mine).

Similarly, Kugler and Laub (1971) observed theta activity in children from 6 months to 6 years while watching puppet shows and similar

experiences. As age increases, the speed of the theta increases from 4 to 5-6 c.p.s. and moves from being maximally developed over posterior regions to central or precentral areas.

> "The series of theta waves manifest themselves at the onset of attentive perception of the visual or auditory stimuli and diminish within a few seconds but may reappear later. The precipitation of these theta rhythms is also determined by environmental factors. If the unsedated and initially tense children become mentally and physically relaxed (under the guidance of an experienced technician) theta rhythms can be consistently triggered unless there are cerebral disorders and EEG abnormalities. Theta rhythms are absent when the children are distracted by additional environmental stimuli" (p 533)

They could also distinguish this theta activity from that seen in early drowsiness. Their conclusion was that "these theta rhythms demonstrate that essentially similar EEG signs may be due to different basic mechanisms determined by distinct sets of exogenous and endogenous conditions" (p 533, emphasis is mine). This latter emphasis serves to introduce the current theoretical dilemma with the interpretation. Problems here began when studies showed theta activity appearing or increasing in direct relation to 'cognitive', problem solving tasks. This was a far cry from previous phenomena although as early as 1951 Mundy-Castle noted "augmented theta activity during . . . mental effort." (p 479 reported in Schacter, 1977, p 55 and 72). A range of psychophysical tasks has resulted in augmented theta activity, although not reliably. These tasks have included reading and mental arithmetic. Theta has therefore been implicated in states as seemingly diverse as the hypnagogic, and sleep deprivation through perceptual processing to the 'higher' functions of learning and memory. (Schacter, 1977)

That this frequency band could at one and the same time indicate both a high and low level of purposeful intellectual function creates a

conundrum which screams out for conceptual clarity and resolution. But there appears to be no such phenomenon in the literature. Schacter's masterly review of the facts succeeds only in eliciting the traditional limp request for more, and more careful research. It would appear from the already available empirical data that more of the same, unguided by a clear theoretical framework could only increase the confusion.

(i) The Hypnagogic State

In an effort to explain the theta phenomenon let us first review the cases where theta is clearly and reliably a dominant feature of the EEG record. These come under the umbrella concept of the hypnagogic state. The hypnagogic state shows a multiplicity of phenomena which occur in the context of the interval between waking and sleeping. This overview is derived from Schacter, 1976.

At the EEG level there appear to be stages, generally descending but not beyond the point of totally losing awareness of the external environment. There is depression of alpha activity with a corresponding increase in theta and beta activity. This diffuse theta may not appear until well after the onset of occipital alpha blocking. Schacter considers there to be sufficient coherence between the reports to conclude that the "gross EEG characteristics of the hypnagogic state are known". All cases show "a loss of amplitude, frequency and synchronous repetition." (p 472) We can summarize the pattern as $\rightarrow\theta\rightarrow\alpha\rightarrow\beta$ although sometimes only $\rightarrow\theta\rightarrow\alpha$ has been reported. One point which emerges strongly from this literature is the correlation between alpha and contact with, or awareness of, the external field. When subjects report having lost consciousness of the environment, the reduction in alpha is compensated by some mixture of theta and beta activity. Schacter views this superimposition of fast

beta waves onto the theta as another problem for future comprehension and suggests studies of "The proportion of theta-to fast frequencies in relation to psychological function" (1977, p 51), that which is attempted here.

In contrast to the alert waking state though, introduction of sensory stimulation in the presence of low voltage theta activity induces alpha activity. As he notes, this phenomenon is important for understanding theta (Schacter, 1977, p 49) to which we must add, for understanding the various patterns of cortical activity in which theta may appear. There is consensus that "an important cognitive correlate of the hypnagogic period concerns the organism's decreasing ability to interact actively with the environment" (1977, p 49). As we would expect from this, verbal material presented during this state, after theta has replaced alpha, has a lower probability of response and recall than when alpha is significantly present.

Awareness of the field however, is not to be equated with 'eyes open'. Clearly it is possible in the normal waking state to sit relaxed with eyes closed and be highly aware of one's position in the field.

Slow eye movements (SEM's) particularly of the 'rolling' variety have been found to accompany the hypnagogic state. When these were absent, S's invariably claimed to be awake and 'thinking'. Reduction of 'thought' and qualitative changes in mentation are commonly reported. Low levels of frontalis muscle activity also accompanies the theta abundance. Entry into the hypnagogic state appears to depend on a reduction in the level and variety of sensory and proprioceptive input, ability to move into a state of 'passive volition' and a shift from

dominance of sympathetic to parasympathetic nervous system. Monotonous or homogeneous stimulation is a successful trigger.

Observations that the rules of association differ radically in this state from that of normal waking and that they are similar to those observed in schizophrenia, suggests a shift in the balance of activity in the two hemispheres with an increase of old brain primary process thinking, relative to the neo-cortex. (Emery and Emery, 1976, p 89-90) Consistent with this is the efficient but exhaustible nature of the left hemisphere capacity for vigilance (Diamond and Beaumont, 1973; Krugman, 1979) and Luria's analysis of the hierarchy of associations (1981, p 73-82). In the normal waking state there is a process of selectivity for situational and connotative associations. When the cortex (particularly the LH?) is in an 'inhibitory' oneroid state, this selectivity mechanism fails to operate and phonetic associations arise with equal facility. This is tied to Luria's theory of memory loss as a surfeit of data, surveyed above.

Closely related to the hypnagogic state is the 'autosymbolic phenomenon' which is "occasioned by the struggle of two antagonistic forces; drowsiness and the effort to think." The effort to think may not however be necessary. (Schacter, 1976, p 467) Abstract mental contents are transformed into concrete visual images. More generally, many researchers have noted that in such conditions, external stimuli are easily recruited into the imagery process and the drowsy theta state renders people unusually susceptible to external suggestion. This is particularly so for 'emotional' rather than 'intellectual' suggestio (p 468). One careful experimental study has shown a direct relation between affect and theta. Using 'emotional' and 'neutral' words they

found that stimulus emotionality and slow wave activity bear a "U"-shaped relationship to both the awareness and recognition thresholds. The rise and fall of theta abundance prior to awareness of high and low threshold words appears to reflect the emotional arousal occasioned by those words. There were corresponding decreases and increases in alpha activity. Postulating a single process, they saw the momentary suppression of alpha as a lowering of the cortical discrimination threshold. (Dixon and Lear, 1964) There is therefore some support for the early formulations which emphasized the affective nature of the theta response.

Clearly in the terms used here, the hypnagogic state can be described as a period when there is relative freedom to explore or wander over the whole set of directive correlations. Once established, external events appear not to redirect the person to more strictly purposeful behaviours but are merely incorporated into the process with a minimum of critical evaluation. Sleep deprivation results in a similar EEG pattern although delta is mentioned here also, and beta shows little change from normal. ($\blacktriangle\theta\blacktriangledown\alpha.\beta$) Errors of omission occur more frequently during episodes of high theta and delta, predominantly theta.

Theta may be varied by special training which by its nature exploits a repetitive signal, for example, the mantras. It has been studied in the context of hypnosis, meditation techniques and has also been the subject of biofeedback training and control. This area of literature has proven to be a rich source of information and hypotheses but it is marked by inconsistencies (Schacter, 1977). Hypnosis, a state of narrowly focused attention, has shown some increases in theta which confirms the link with suggestibility, but there are huge individual differences. Experience with various forms of meditation and training is variable with some

researchers arguing that the EEG patterns are typical of drowsiness or hypnagogics; other argue for an alert but qualitatively different th state. Specific autogenic training has also brought mixed judgements. Theta has also been found more difficult to bring under conscious control than other frequencies (Brown, 1971; Johnson, 1979, p 384; Green quoted by Schacter, 1976, p 458).

Further evidence has been surveyed by Elson, et al (1979). Relating to our purposes here, they discuss the transition to sleep from an alpha state to an alpha-theta state and the phenomenon of 'functional blindness' found by Rechtschaffen and Foulkes in 1965. Even with eyes taped open, the subjects no longer saw pictures held in front of their eyes during the later parts of the alpha state (p 218). "This would suggest that sleep onset occurs already during the alpha state (if sleep is defined as a relative lack of reactivity to the environment" (p 219). But more commonly this state is viewed not as sleep proper but only a transition. Aroused from this state people will report that they were awake, not asleep. The so-called 'theta state' is another lower intermediate state. Using a simple 3-way classification of (a) full arousal (low voltage random fast, beta EEG), (b) 'alpha-theta' (the transitional stages between awake and asleep characterized either by more than 50% alpha waves or by a predominance of theta activity on a low voltage mixed background) and (c) unambiguous sleep (stage 2 sleep, characterized by spindles and K complexes) Elson et al tested the difference between experienced mediators and controls. They distinguished 'descending' or hypnagogic alpha-theta (that which led to stage 2 sleep within 5 minutes or less) from 'non-descending' alpha-th which could be held constant without resulting in a fully fledged sleep. A direct relationship between training in meditation and ability to

produce theta in a stable, non-descending state was found. Controls, untrained in meditation quietly went to sleep.

Subjective reports by persons trained in theta, include descriptions of hypnagogic-like imagery and reverie or wandering in imagination which might be characterized as creative thought patterns" (Sheer, 1977, p 437). However, given all the other data on theta this may be an over optimistic interpretation, based more on feelings of pleasure than on proven relation to creative thought which implies some purposefulness or directed activity. Other subjects have simply reported feelings of drowsiness (Johnson, 1979). Indeed the overall tenor of discussion in the papers collected by Beatty and Legewie (1977) is extremely cautious as to the benefits of various training methods for either experimental or therapeutic purposes (Legewie, 1977). Plotkin (1977), for example, has shown that psychosocial factors in the experimental situation contribute more to the subjective value of alpha enhancement training than the amount of alpha produced. He notes the "fascinating resemblance between the alpha feedback phenomenon and the hypnotic situation" as processes of social influence (p 131). Thus while biofeedback has not proven its early optimistic promise, the studies which have more carefully replicated and reviewed the phenomenon have tended to reinforce more traditional concepts of the role of the frequency bands, and particularly theta, in terms of wakefulness, sleep and associated states such as the hypnagogic.

(ii) Theta Training and Vigilance Performance

"The 'vigilance decrement' is the gradual, unconscious loss of the ability to react effectively to infrequent, unpredictable but critical events in passive, monotonous work. It was first identified from records

of hostile submarine contacts reported by surface and airborne British radar operators during World War II." (O'Hanlon et al, 1977, p 14) This was followed by the early classic work of Mackworth (1950) but later studies using college students "who performed simplistic monitoring tasks in impoverished laboratory environments" appeared to have lost sight of the critical nature of vigilance research for many aspects of modern human life. Norris, a former pilot, expresses several times in his book The Unsafe Sky (1981) his astonishment that air traffic controllers did not 'see' what was happening on their screens. They had lost the minimal level of vigilance and were to all extents and purposes in something approaching a hypnagogic state where external stimuli finally are incorporated into the review of the total set of directive correlations, rather than being evaluated as features for biological survival in an immediately present environment. As the presence of theta activity could be expected to indicate that vigilance has dropped and that the controllers had 'locked into' the repetitive stimulus of the technology, it would be expected that some decrement in performance would be observed.

In a series of experiments designed to recapture the realism of earlier work, Beatty et al found that theta was indeed correlated with performance in vigilance tasks. The first study used naive college students and a radar simulator which was however, a cathode ray tube, 23 cm in diameter. S's were trained in the sea-surveillance task and assigned to one of two experimental groups where they learned to suppress or augment theta activity. Each group then performed the two hour vigilance task with regulated and unregulated EEG. "Striking changes in monitoring performance accompanied regulation of theta activity . . . (showing) the incidence of theta frequency activity in the occipital EEG

is inversely related to monitoring efficiency." (Beatty et al, 1974, p 872) Theta suppression also appeared to most benefit those who are otherwise most likely to show degraded performance.

Because of the highly selected nature of the radar operator population, their experience with learning to maintain vigilance and their motivation to succeed (compare the helicopter pilots discussed above) a further two-stage research programme was designed to replicate the findings with skilled operators in an operational environment. While there were some slight differences in method over the series, none appears sufficiently significant to affect the basic relation between theta and performance. S's were drawn from the elite of the US navy radar operators, all of whom had worked alone for periods of 8-12 hours. Test time was three hours in duration. Results of the first replication paralleled the first study although the skilled group were, before theta training, more proficient than the students. Increase in monitoring efficiency was shown to be specific to the theta conditioning.

The second replication used normally occuring radar presentation with noise, interferences etc, along with air traffic. Here the feedback was found to suppress theta activity but had little effect upon their detection performance, a result described as "disconcerting" (O'Hanlon et al, 1977, p 160). Two deviant operators who showed the least proficiency and greatest decrements did however, show a beneficial increase in detection with theta suppression.

Over the series as it moved towards total operating realism, the strength of the inverse relation between theta and detection declined. Several interpretations have been made. The original team speculated that

perhaps their experienced operators were already operating at the maximally possible level of vigilance. But deficits were noted o time. Lawrence and Johnson (1976, quoted by O'Hanlon et al, 1977, p 162) pointed out that "in fact, it appears that a performance decrement is a necessary condition for the observance of any theta effect." In other words, as with the onset of the hypnagogic state, awareness of the environment must be reduced before theta appears in the records. In reviewing these and other studies Johnson (1977, 1979) recentred the results within the traditional concept of theta as indicative of a drowsy period and relaxation, and that training to produce theta waves has a potential value in inducing sleep (p 385). Johnson's conclusion is as follows:

> "I believe that EEG theta activity is an epiphenomenon of a general lowering of arousal level. Until it can be clearly shown that theta activity is uniquely feedback contingent in a subject who shows no other physiological changes of lowered arousal, it would appear most parsimonious to view changes in arousal level as the response being controlled." (1977, p 82; 1979, p 386-7. My emphasis)

Leaving aside the training aspect of these studies it is clear that theta activity and vigilance performance are inversely related and that even some of the most highly selected, skilled and professional operators will suffer decrements in performance while working with CRT technology.

(c) Theta Appearance in 'Cognitive' Tasks.

Table 13.1 presents the results of a survey of the available literature of cognitive functions and the EEG. Some cases are not included here because the data are incomplete.

Table 13.1 Lack of Relation between Pattern and Task

Pattern θ	Pattern α	Pattern β	%	Tasks
⌓	⌔	⌓	26	MA(4) VR(2) DW(2)R, AM, WW, AT, WL
⌓	⌔	⌔	22	MA(2) WW(2) KB(2) AM, AT, VT, VP, ML
⌔	⌔	⌔	10	WL(2) VR, DW, MA
⌔	⌔	⌓	10	MA(2) LM(2) VD
⌔	⌓	⌓	8	DW, WW, AT, VT
⌓	⌔	–	4	MA, AM
–	–	⌓	4	FB, AT
–	⌔	⌓	4	LV(2)
⌓	⌓	⌔	2	KB
–	⌔	–	2	VL
⌔	–	⌔	2	TM
⌓	–	⌓	2	ES
⌔	⌓	⌔	2	MA
–	⌔	⌔	2	VP

Where: AM = auditory memory; AT = acoustic tracking; DW = drawing a wavy line; ES = Etch-a-Sketch; FB = formboard; KB = Koh's Block Design; LM = listening to music; LV = listening to verbal (speech); MA = mental arithmetic; ML = mentally composing a letter; R = reading; TM = tonal memory; VD = visual discrimination; VL = verbal listening; VP = viewing patterns; VR = visual reasoning; VT = visual tracking; WL = writing a letter; WW = writing complicated test word.

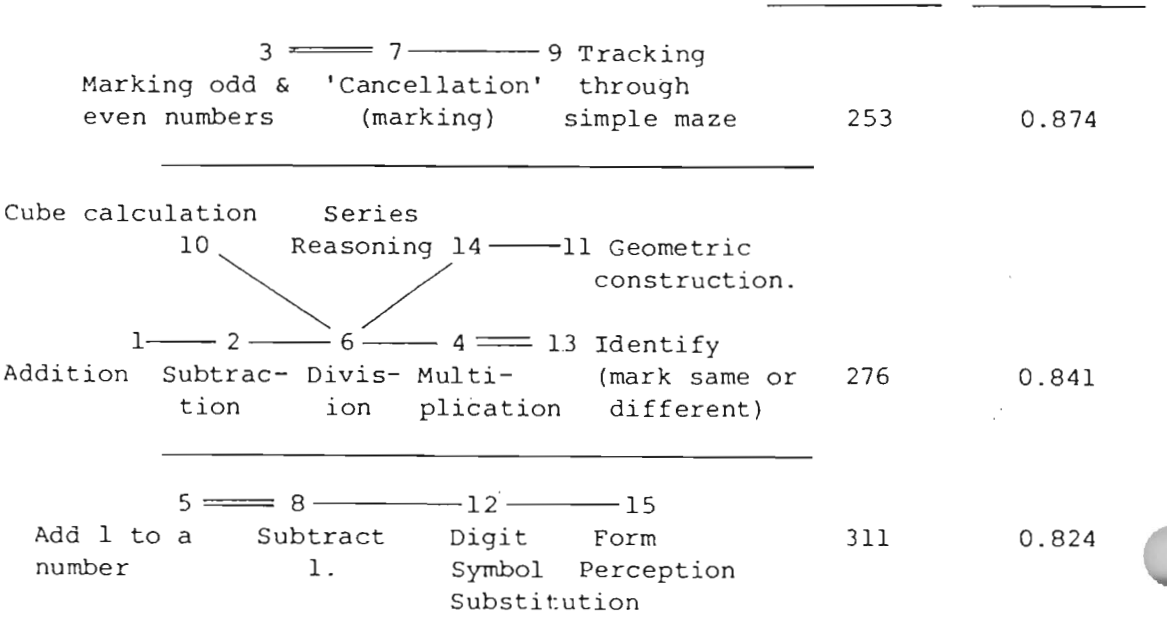
The main conclusion is obviously that EEG changes do not reflect particular forms of mental activity as it has been traditionally conceived by cognitive psychologists. Mental arithmetic, for example, has produced six distinct patterns of change. That tasks may relate in ways which do not conform to psychological assumptions is confirmed below by a re-analysis of Ishihara and Yoshii (1972). The two most commonly found patterns covered eight different tasks. By far the most coherent result was a decline of alpha activity in 80% of cases. It increased in only 12%. Beta activity increased in 54% and decreased in 40%. Theta increased in 56% and declined in 32% (Delta was not included in this summary because of the relatively few cases reported. Those can be found in the full table below.) Such a lack of relationship between EEG pattern and task cannot be totally explained away by the use of different types of measures, power or frequency for example, nor by the varying

location of electrodes. Either, there is no patterning to varying forms of mental work, or the EEG is measuring something entirely different. But as we know that rCBF studies have identified reliable patterns of metabolic change with various activity, we must conclude that the EEG has been basically misinterpreted.

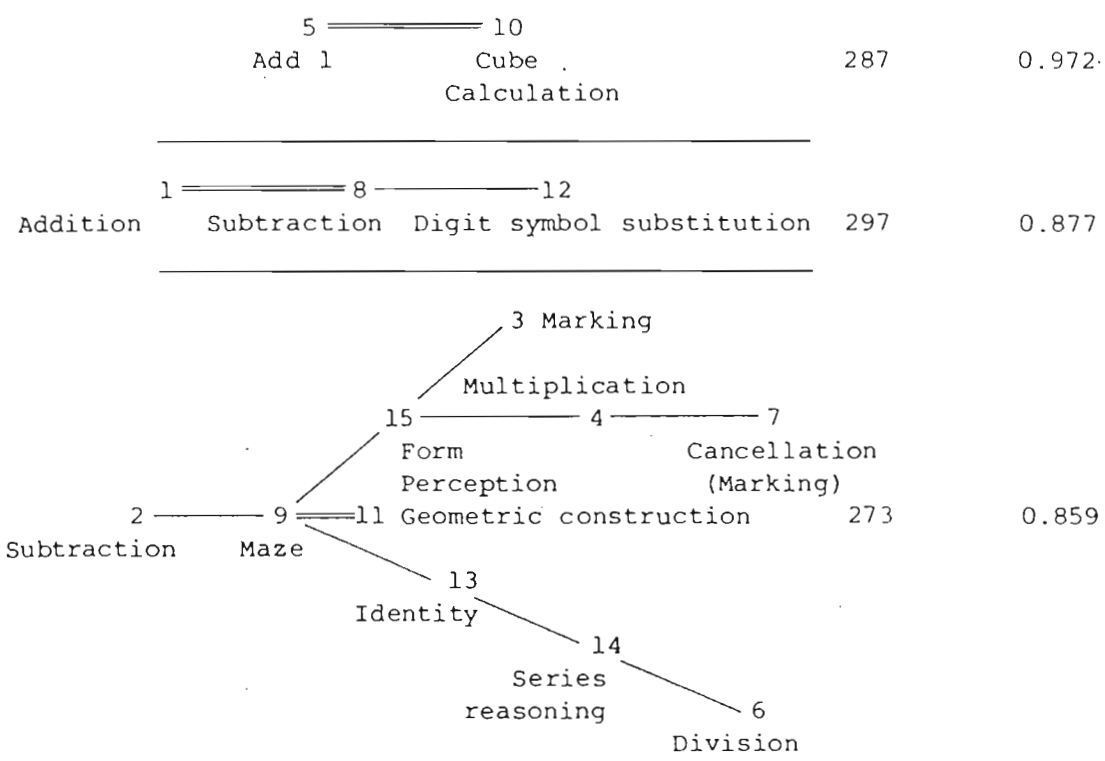
Ishihara and Yoshii (1972, p 76) present some data which tends to support this view. Analysing their two correlation matrices by causal path analysis (Emery F, 1981) we find two separate sets of clusters within their fifteen sub-tests of mental arithmetic. There is some minor overlap between that set derived from the test scores and that from the theta scores but not sufficient to conclude that theta was related significantly to performance. Once the uni-solution graphs were extracted from the matrices, the average theta correlation for each cluster was calculated from their Table V. This is a test of coherence.

Figure 13.1 Relation of Theta to Work in Mental Arithmetic
(from Ishihara & Yoshii, 1972, p 76)

(a) from test scores



(b) from theta scores



The average theta score has been estimated from their Figure 4 (p 75). The graphs shown in Fig 13.1 are those from the first order matrices as presented. A hierarchical linkage analysis was also performed which showed in both cases that the fifteen sub-tests were all linked in a single pattern of mental arithmetic. We notice in this figure that there is only some overlap between the clusters cohering in this data and the four factors for test scores,and the two factors for theta scores extracted by Ishihara and Yoshii. This method indicates that tests are related in ways that do not necessarily conform to our theoretical expectations. There are three clusters within each matrix. It is doubtful if these clusters would have been predicted. From the test scores matrix, there is a clear inverse correlation between the coherence measures and the theta scores. The cluster which had the highest theta score is that which appears to be the most repetitious or highly structured; that is, add one, subtract one and digit symbol substitution, etc. The 'marking' cluster which includes tracking through the maze

which would appear to have the least of these characteristics has the lowest average theta score with the highest level of coherence.

A similar pattern is found with the clusters from the theta scores matrix although the inverse relation does not hold. The marking items fall into the bottom cluster which has the lowest average theta score. Highest average theta score is associated again with digit symbol substitution and addition and subtraction. As digit symbol substitution was not difficult "but required mental functions such as rapidity of perception and discrimination, simple memory and writing" (p 79) Ishihara and Yoshii concluded that it required "continuous concentration of attention". Showing most frontal midline theta activity of any subtest, they inferred that this phenomenon was associated with duration of attention. From their discussion of other research in which frontal midline theta occurred, it is associated with tasks in which S's were already highly skilled, or for whom the task was very easy and routine or automatic.

Returning now to the literature review, the question must be, what features of these tasks lead to such a pattern of results and how do they relate to the appearance of theta wave activity and to theories of human function. As we shall see below, there are features common to these tasks which support an interpretation of theta appearance and further, lead to a concept of EEG patterns as the visible signature of the operation of a set of scanners over the various levels of consciousness.

Because there is little coherence between pattern and 'cognitive' functions Table 13.2 summarizes the results in no particular order. From this extended table, some consistencies emerge concerning the appearance of theta activity. There is clearly a factor associated with

Author	Task	Pattern	Area	Remarks	Discussion and Interpretive Comments
Gevins et al 1979(c)	Mental arithmetic. Addition called "a logical task" (p 666)	↑Θ↓α↓β	Total scalp	Measured spectral intensities. Task time very short. Method criticized elsewhere herein	Across all tasks they noted α and β suppression and enhancement of Θ. There was however, an increase in β during arithmetic in the frontal leads (F3+F4). As they note this has been associated with 'non-idling' of an underlying cortical region and is consistent with rCBF studies.
Dolce & Waldeier 1974	Mental arithmetic (eyes open) Silent Reading (a novel, reflected light	↑δ↑Θ↓α.β ↑δ↑Θ↓α↑β small	pre- + central LH + above the gyrus angularis. Occipital in both hemis.	Used % of frequency band intensities	Theta was more pronounced with reading than with arithmetic. δ was more pronounced with arithmetic. They suggest α as "a non-specific functional readiness" (p 581). Theta was more pronounced posteriorly. δ "may serve a limiting function which eliminates endogenous or exogenous influences that are not useful to the task performance." (p 581) Dolce et al speculate that theta was related to the content of text.
Stigsby et al, 1977	Visual Reasoning. EO, reflected. Detection of geometric figure without common feature. Auditory Memory, Ec, lying supine, detection of 3 consecutive odd numbers.	↑δ↓Θ↓α↓β ↑δ↑Θ↓α↑β small ↑δ↑Θ↓α↑β ↑δ↑Θ↓α↑β ↓δ↑Θ↓α↓β ↑δ↑Θ↓α.β	Frontal Temporal Occipital Frontal Temporal Occipital	Measured power, frequency + 'complexity'	EEG changes seen in the temporal region do not fit with rCBF studies which found only small changes in that area with reasoning tasks. But the EEG results may be due to temporal involvement in visual pattern discrimination. The discrepancy does fit a theory that EEG patterns reflect the constantly changing patterns of scanners responding to features of the internal + external environments. rCBF may well indicate different patterns of activated tissue for tasks varying between localis structures such as Wernicke's area. It would then be a true measure of activation while EEG reflects psychological profile of transformative processes relating system and environment.
Walter et al, 1967	Viewing slides for one and 3 seconds	↑Θ (lower frequency higher in power & narrower band width	LH + RH measures across a range of sites	Used 3 parameters of 'power' mean frequency + band width.	Coherence of theta, and some delta, indicated a direct relatio between theta and the stressful nature of the visual tasks and discriminated the shorter more stressful from the longer. They suggested a deep generator of theta wave, the hippocampus, was activated by the stress and radiating to the separate parieto-occipital and vertex leads. The study used both individual and group analysis of records and showed the variability of individual EEG patterns or 'signatures'. Hippocampal theta has now of course, been confirmed. Intensity of affect was a factor in this study.

Table 13.2 continued.

Author	Task	Pattern	Area	Remarks	Discussion and Interpretive Comments
Legewie et al, 1969	Drawing wavy line	↓θ↑α↑β	temporo-occip(t-o) fronto-central (f-c)	All LH. Measure is the % change in no. of waves	Major effect found was classical reduction in alpha activity from closed to open-eyed conditions. However, the analysis performed by pattern presents two cases where all three frequency bands decreased from the resting condition. Both cases were with eyes open with measures from the f-c areas. δ activity was not measured but as the instances stand they must be unusual. The pattern represents a generalized diminution across a wide spectrum of frequencies. The opposite case of Adey et al, 1967 (↑θ↑α↑β) was interpreted as strong arousal to novelty. Presumably, these cases may represent low arousal with repetition and overlearning.
	" EC	↑θ↓α↑β			
	" EO	↓θ↓α↓β small			
	" EC	↑θ↓α↑β			
	Writing complex test word	↓θ↑α↑β	t-o		
	" EC	↑θ↓α↑β	"		
	" EO	↑θ↓α↓β	f-c		
	" EC	↑θ↓α↓β small	" small		
	Mental arithmetic, repeated multiplication	↓θ↑α↓β	t-o		
	EC	↑θ↓α↑β	"		
	" EO	↓θ↓α↓β	f-c		
	" EC	↑θ↓α↑β	"		
	Accoustic Tracking, EO	↓θ↑α↑β	t-o		
	" EC	.0.α↑β	"		
	" EO	↑θ↓α↓β	f-c		
	" EC	↑θ↓α↑β	"		
	Visual Tracking, EO	↓θ↑α↑β	t-o		
	" EO	↑θ↓α↓β	f-c		
	(radiant light source)				
Gevins et al, 1979(a)	Koh's Block design (from memory, RH only)	↑θ↓α↓β	F, c + p	Measured spectral intensities.	This analysis summarized in Gevins and Schaffer (1980) differs from that presented above under Direct Testing which was taken from Table 1, which does not report site differences. Gevins et al (1979(a)) also report (p 697) that "all tasks suppressed alpha activity" but 15 S's out of 23 showed an increase in alpha. Similarly from Table 1 (1979) we find that not one S showed a decrease in β in any test. There are obviously majc discrepancies due most probably to location of electrodes.
		↑θ↓α↓β	o		
	Writing from Memory.	↓θ↓α↓β	f, c + p		
		↑θ↓α↑β	o		
Volaka et al, 1967	Mental arithmetic (i) without reward	↓θ↓α↑β	RH p-t.	Measure of abundance	β distinguished between the two test conditions and showed decreased variability with higher abundance. They concluded that beta activity is more closely related to general level of activation than other frequency bands.
	(ii) more difficult and with reward.	↓θ↓α↑β			
	Eyes closed, serial subtraction in both cases.				

Table 13.2 continued.

Author	Task	Pattern	Area	Remarks	Discussion and Interpretive Comments
Vogel et al, 1968	Mental arith. Simple and difficult subtraction.	θ was found	LH, o + p.	EC. Prone Measured no. of waves.	Two separate studies are reported with slightly differing results. Beta was high, above 17 Cps. Sβ was not measured. β was inversely correlated with automatization. Efficient performance on the difficult subtractions was associated inversely with α and directly with slow waves.
Doyle et al, 1974	Writing letter (visual motor) Mentally composing letter, EO Fixated Modified Koh's Blocks Modified Minnesota paper Form Board test Serial arith. Multi-+ Div. Verbal Listening & answer questions Seashore Tonal memory Magic Etch-a-Sketch (reproduce given design on manually controlled x-y plotter)	↓δ↓θ↓α↓β ↑δ↑θ↓α↓β ↑δ↑θ↑α↓β ↑δ.θ.α↑β ↑δ↑θ↑α↓β .δ.θ↑α.β small .δ↓θ.α↓β ↑δ↑θ.α↑β	LH + RH p + t. Only T3 reported here	Measure was average relative power levels. Quite similar patterns were obtained from p + t leads.	Most striking pattern was the elevation of theta power levels in all leads in the spatial motor tasks Blocks and Etch-a-Sketch; δ was also elevated for Blocks. "This may well be due to the large number of small scanning eye movements typical in this task." (p57 - an indication of concentration and lack of awareness of the field. Motor tasks all tended to depress alpha, non-motor tasks and rest raise it. The pattern of β found is "contrary to the commonly held view that cerebration increases beta: we find less beta over the hemisphere more primarily engaged." (p 576) This finding is of course consistent with a hypothesis that β scan of the total set of directive correlations will reduce when extreme intensity of task orientation is required.
Thompson & Obrist 1964	Verbal learning of nonsense syllables by serial anticipation. Overlearning. (Additional 20 trials following 1 errorless learning trial).	↓α↑β↑Sβ ↓α↑β↑Sβ	o.	Not enough θ to warrant analysis. Sβ= superimposed fast wave activity. Measure was no. of waves	Highest ratio of β+Sβ:α was 2.07 in the learning trials. It dropped to 1.95 during overlearning which was still above rest and control conditions (1.61 and 1.69) Alpha decreased and β and Sβ increased during learning. (↓α↑β) There was no clear pattern of change during overlearning, probably because some syllables were still being learnt at the start of overlearning (p 337). There were reports of increased concentration during the 3rd quarter of the trials when dropped, indicating that task orientation results in lowered environmental vigilance. Contrary to expectations, EEG activity during overlearning failed to return to control levels because of possible still continuing learning or because non-sense syllables were employed. These would require continuing beta scan for meaning relative to 3 letter 'words'.

Table 13.2 continued.

Author	Task	Pattern	Area	Remarks	Discussion and Interpretive Comments
Mizuki et al, 1980	Mental arith. Continuous Addition	↑θ . No report of α or β small	Frontal midline	Measured wave form, amplitude and duration	Frontal midline theta (Fmθ) was not correlated with performance. It took 11 secs. to appear in 63% of S's. It was however, correlated with concentration. Fmθ showed a periodicity, could be a basic biological rhythm (p 349).
Gianni-trapani 1971	Mental arith. Silently performing probs. Listening to Music. Listening to verbal contextual material small mixed	↑θ↓α↑β ↑θ↓α↑β small ↓θ↓α↑β small ↓θ↓α↑β .θ↓α↑β θ↓α↑β	prefrontal temporal p-f t p-f t	Occipital changes were smaller than for prefrontal + temporal for 3 conditions, but same pattern. Measured log amplitude scores.	The effects observed primarily in the high beta frequencies (above 25 cps) is consonant with the Sβ of Thompson and Obrist (1964). Interpretation is discussed in text.
Gale et al 1975	Viewing visual patterns for later recognition.	Increase in no. of elements: ns ns ↑θ ↓α↓β Increase in variety of Elements: ns ns θ ↓α↓ β	trans-occip.	Projected slides, reflected light, Abundance values	The more stimuli that are differentiated in terms of EEG abundance, the more efficient is subsequent recognition (p297) EEG changes therefore have functional significance. Results for theta increase with number but not variety suggest θ is involved in repetitive work
Adey et al, 1967	Visual discrimination tasks in the lab. Flight GT-7, Space flight records	↑δ↓θ↓α↑β Before launch + first orbit ↑θ then joined by ↑α + β. Then ↓θ but episodes of ↑θ	From vertex to occiput. θ found in posterior sites.	Spectral density analysis with calculations of coherence. Using their awake records only.	The pre-launch pattern was interpreted as strongly focused attention and orienting responses in a novel situation; a strong neurophysiological arousal reaction. Beta increased later in flight. Russians showed increased beta with no change in theta but no lead positions were given. Also found profound autonomic changes interpreted as environmental stress.

concentration or strongly focused attention, repetition, automatization and over-learning. It includes also some overtones that this factor is affective in nature and especially related to distress (usually called 'stress'). Freedman et al (1966) who found theta appearing in a control group, suggested its origins lay in frustration induced by lack of feedback (Schacter, 1977). We should also note here Walter et al (1967) to the effect that their shorter task time obviously required greater concentration and was described as more stressful. An obvious interpretation is that periods of extreme concentration or focusing are experienced by many as distressful. There are exceptions, but as it is difficult in many cases to extract clear pictures of the exact nature of the tasks and the more subjective descriptions of S's orientations, it is possible, for example, in the case of Volaka et al's test of Mental Arithmetic, that some aspect of the task or experimental situation lead to its being less distressful. And, as there are no guidelines to sensitivity to repetitive and deviant stimuli, any sample may be weighted more or less towards normality.

It is important to note several points which can be made about the picture which emerges here. The first is that most of these experiments used exceptionally simple, narrow or overlearnt tasks, in the hope of finding the pure functional EEG equivalent. Very few are or could be described as learning. Most are simply 'doing' or paying attention to low level mechanical (intellectual) or perceptuomotor tasks. Those which could generally be considered to be more 'learning' than 'performing ' are more likely to show a pattern which includes beta increase. Amongst these are Thompson and Obrist (1964), Ginnitrapani's (1971) listening to Tchaikovsky and readings of Tom Sawyer, Dolce and Waldeier's silent reading. Schacter's (1977) review of theta similarly shows that beta

increase and theta decrease is a more prevalent finding in 'learning' than in perceptual processing or problem solving. If theta is associat with a factor such as that described above then it is logical that 56% of the cases involve an increase of theta activity.

3. Interpreting Theta Activity

(i) Common Threads

While the hypnagogic state and those others variously described here are at one level vastly different in character, there are obviously some overlaps in the interpretation of theta appearance. The first is the generality with which an increase in theta is inversely correlated with alpha activity. This appears to be a reliable indicator of the hypnagogic state and in these records of cognitive task, performance ranges from 40-52% of cases, depending on whether instances of no chang are included. When external stimulation is applied in the hypnagogic state, there is an increase in alpha which can be interpreted as a return to environmental vigilance. If we postulate that extreme levels of concentration or focusing on a narrow task reduce awareness of the actual environment, it follows that presence of theta may also reliably indicate loss of awareness of the surrounding environment. This fits well with Maulsby's (1971) observation of theta associated with staring with no distractions and also with Kugler and Laub's (1971) claim that slightly different frequency dominances within theta activity could be determined by distinct sets of exogenous and endogenous conditions (both studies discussed above). This becomes clearer as we distinguish between vigilance and attention; a distinction which is critical to perception (Chapter 1).

As Chein (1972) pointed out, attention has been used to cover three distinct kinds of processes. The first describes the case where the range and variety of available objects to which a person is responding becomes limited; the more limited the range, the greater the attentiveness. In the extreme case of attending, in this sense, the person is unresponsive to all but one of the available objects in a field. In other words, attention here is marked by the exclusion of certain things from the immediate perceptual (behavioural) field and the person can be said to be in a state of low vigilance. This describes accurately the common response to television. Chein's second meaning concerns the discrimination of the relationships between an object, as figure, and its field and is that state traditionally called vigilance. Essentially, the person's attention is focused on the field in such a way that objects or events are highly articulated, a process of tracking or monitoring the key features of the environment. It is possible to be vigilant and attentive, in the first sense, simultaneously, but should a moment of consciousness take place it will interfere with the process of attending. The third meaning is that of duration of attention in either the first or the second, vigilance, sense.

Theta abundance observed in these test situations is closely associated with narrowly focused attention and lack of vigilance in the sense of environmental alertness or scanning. Both the tests and the hypnagogic state therefore represent a state of heightened attention and lowered vigilance; the former due to exogenous, task-oriented conditions and the latter due to the endogenous conditions of attending to internal mental processes. This is consistent also with the work on radar monitoring which showed that an increase of theta was associated with a decrement of performance in vigilance or scanning.

Clearly tied to this argument is the second common feature; the nature of the trigger for theta activity. The hypnagogic state can be induced by monotonous or homogeneous stimulation or environment. In the tests with which theta increase has been associated, 'repetition' and 'automatization' are the terms used.

Thirdly, there is the relationship of theta activity to the affect system. Affectual phenonema are prominent during the hypnagogic state and are mentioned in discussion of the 'cognitive' tests. One of our problems here of course is the fact that cognitive psychology has been sharply distinguished in theory and practice from affective or personality psychology. Within the paradigm employed here, this distinction cannot be made. All human phenomena are affective just as they are all cognitive. There are only different levels and patterns of human behaviour. We have examined factors which deal with individual differences in these varying states. But the point at issue here is simply that very similar 'affective' phenomena are noted with theta in cognitive tests as have been traditionally associated with its occurence. Frustration and distress echo precisely early findings.

These three points of coincidence between the hypnagogic and test conditions, namely

(i) increase in focussed attention with reduction of vigilance of external environment
(ii) triggered by repetitive or homogeneous stimuli, and characterised by
(iii) obvious signs of 'affect'

are sufficient to support the conclusion that while theta may show some varying characteristics of band width, dominant frequency etc, between

the two states, there is a theta activity phenomenon which may be found in such disparate states of behaviour.

This is supported by Brown (1971, table 1, p 455) who found theta was associated subjectively with both solving mechanical or financial problems and daydreaming amongst other activities. She reports that theta presented more difficulty that alpha or beta. Theta or slow wave activity may come into play therefore in a very specific set of circumstances which is marked by a relative absence of environmental awareness or vigilance.

This reconciliation between the hypnagogic and cognitive tests states cannot be maintained or elaborated into new theory unless we return to, and take further, the discussion of consciousness and remembering outlined in Part I. It has become necessary to take stock of our concept of 'thinking'.

(ii) Theta Activity and 'Thinking' in the Ecological Paradigm.

We need now to re-examine our theoretical framework and ask how the concept of thinking or reasoning is explicated within the ecological paradigm. The data presented here provide no evidence for distinct mental faculties or functions. Are these data perhaps comprehensible within the model of consciousness presented in Part I? Arguing from Chein and the Gibson school, I concluded that beyond specifying consciousness as the ability to perceive oneself as an environmental event within the hierarchical set of directive correlations together with a set of transformational processes which follow the laws of perception, there is no need for a set of separate concepts such as thinking. Thinking and perception are to all extents and purposes inseparable (De

Bono, 1979, p 82). Cognitive psychologists have refrained from attempting to tightly structuralize 'thinking' as they did memory and has remained a shadowy, ambiguous entity which appears in the guises of logic, reasoning, mental effort, etc.

In layman's language (which is reflected in dictionary definitions) we have been 'thinking' when we can report on what we have been doing or perceiving in a purposeful manner. This understanding contains two components; the activity has been directed and is recoverable, or available to conscious persual. Such a useage covers all the various perceptual acts of imagining, expecting and reminiscing, etc. It is used therefore when the person can specify that they were attending to something. It is not necessary that consciousness be present at the time of the thinking, only that the behaviour can be brought to consciousness. Jaynes' observations that consciousness is not necessary for 'thinking' or for reasoning or insight together with Chein's explanations of subconsciousness have been surveyed to this end. This lay useage of thinking is important because the distinction is clearly made between such directed behaviour and episodes where 'my mind was wondering'. Other expressions include 'I wasn't concentrating', 'I must have been daydreaming'. In terms of the conceptual framework at work here, thinking can be separated out as a subclass of perception and awareness by the emphasis on attention, in both its senses of narrow focus and duration. Thinking is associated only with the waking state. I thus propose a definition of thinking as the act of purposefully perceiving a narrowly focussed object or event in the relative absence of environmental vigilance. Included here would be the moments of actual consciousness when the self becomes an environmental event. Focussing or concentrating on awareness itself, i.e., enjoying those moments of

consciousness, also precludes the scanning of the field as does any intense task orientation.

It is clear however, that vigilance or alertness to the field bears no simple relation to awareness or particularly consciousness. We can be vigilant or alert to critical features of the ecosystem while asleep as is shown by the ability of a mother to awaken upon detection of movement of her baby. But in the waking state, while selection still operates, highly concentrated behaviour will generally correspond to a decrement in vigilance. Chein has spelt out the conditions which limit the appearance of consciousness. These are

(i) the fact that one can only attend to so many things at once. An intense state of vigilance therefore would appear to militate against moments of consciousness.

(ii) where "one is so completely absorbed in an activity that one's threshold of responsiveness to anything else, including the fact of one's absorption is markedly raised; this is of course an extreme of task-oriented activity" (Chein, 1972, p 105).

(iii) Some activities have become "so thoroughly embedded in the higher integration of learning that they cease to be available as potential objects of behaviour unless and until the higher integration is disrupted". The example given is typing (Chein, 1972, p 98). This overlearning leading to automaticity.

(iv) When the behaviour is heavily imbedded in a setting which obscures it. Chein's example is shouting "I'm not shouting" in the middle of a noisy argument.

What is striking about these four conditions in this context is the extent to which they parallel the conditions pertaining to the appearance of the 'theta factor' extracted from tests of cognitive activity, and the correspondence between this factor and the indicators of a hypnagogic state. There is the emphasis on the inverse relation of directed attention and lowered environmental vigilance, the focussing and duration

of attention, repetition and overlearning and immersion in an 'affective' state. This analysis renders the appearance of theta wave activ during 'cognitive' tasks less surprising and suggests a definite and concrete relation to, and within, the possible range of patterns uncovered by the literature search. We may summarize the argument to this point as:

> Thinking: Is perception concentrated on a narrowly focussed object or event with lowered contextual awareness or vigilance.
>
> Theta Wave Activity: Occurs when there is a lowering of environmental awareness or vigilance regardless of scope of scanning of total set of directive correlations.

The commonality obviously lies in the perception of the ecosystem; namely when it ceases to be an object of prime concern or attention. Theta can be taken therefore as an indication of a breakdown in the directive correlation, between the human and environmental parts of the ecosystem.

Before we specify a more precise interpretation of theta we must return to the other frequency bands and their most probable interpretations within this framework.

4. Interpreting the EEG at the Psychological Level

It is possible to reconcile the fact that theta appears in both periods of mental effort or thinking and 'idling' time. Within the paradigm of direct perception and looking at the patterns of wave activity we may postulate correlations of pattern and intellectual state or activity and interpret the functions of the individual frequency bands. Theta appearance becomes more comprehensible in the light of a new perspecti on alpha and beta. The lack of correspondence between separate 'mental faculties' or cognitions and EEG patterns re-raises the question of

interpreting the EEG itself. Stigsby, et al (1977) showed that EEG changes do not always correspond to changes in rCBF. As rCBF appears more reliably and accurately to indicate activated tissue, it may be that the EEG is measuring a related perhaps, but not identical, function or set of functions which are better elucidated at the psychological rather than neurophysiological level.

We need firstly to consider the notion of scanners and the current difficulties with interpretation, particularly of alpha. This will involve translating the concept of scanners from the stimulus-response paradigm to that of direct perception. Brown's (1971) work on the three major frequencies showed that 'response' and 'reinforcement' cannot be identified as separate entities and the response ultimately was awareness of the relationship between subjective activity and the light signals operated by EEG activity, in other words, a moment of consciousness.

(i) Alpha and Beta as Scanners.

Notions of scanning functions have a long and respectable history which has been traced by Thatcher and John (1977, p 71-9)

> 'Although the functional significance of alpha rhythms is still unclear, these results suggest that the alpha rhythm and possibly other rhythms may reflect the action of a scanning mechanism that alternately excites and inhibits adjacent domains of cortical neurons.' (as above, p 72)

Alpha activity has produced some paradoxical results in relation to intellectual activity and memory (Gale, et al, 1974; Tani and Yoshii, 1973) and lack of consensus about the meaning of alpha is evident.

In a series of studies, Mulholland and Peper (1971) showed 'that the "visual attention" hypothesis, which has been advanced to account for the "blocking" of the occipital alpha rhythm is incorrect...' p 568.

> "The changes in the EEG previously attributed to 'visual attention' can be explained in terms of changes occuring in cortical regions that are important for visual control processess..." p 569.
>
> "No reliable change in the occipital EEG in association with saccadic movements was observed in these studies..." p 570.
>
> "Alpha occurs often when there is no pursuit tracking and the near target appears to be indistinct and blurred following instruction to relax accommodation..." p 571. It is usually stronger with eyes closed rather than open and the traditional view of generalized alpha activity was surveyed by Emery and Emery (1976, part II).

Featherman, et al (1979) stated that their results were not consistent with the body of empirical findings and interpret theirs in terms of a hypothesis of dual oculomotor control put forward by Wertheim (1974). Using this duality of external sensory control and control by internal mechanisms "it seems possible that during the reading condition (via TV-my insert) eye movements became so predictable and repetitive that subjects shifted from externally related oculomotor control (attentive) to a state in which intentive monitoring (perhaps memory) become dominant." (p 24). They continue by speculating "that TV viewing, like reading, may represent a shift to intentive oculomotor behaviour" (p 25) with an overall de-activation of the oculomotor system as "learned through long-term exposure, resulting in a dominance of internal mechanisms for the guidance of oculomotor activity" (p 25). These speculations also have significance for theta activity as reviewed below.

Bunnell (1982) has concluded from a series of experiments that while both afferent, visual input and efferent, visual control processes may be

sufficient for alpha block, neither is necessary. Some attentiveness to either external or internal events may be a necessary condition to block alpha however (p 42). Despite years of careful research (e.g., Legewie et al, 1969) the alpha rhythm still defies clarification. This may, as we have reviewed above, be a problem of the 'sensory' paradigm.

The emphasis on attention and control has produced little clarity and may be better replaced by a return to an emphasis on the relation of one or more scanning mechanisms which are directively correlated to ecological states. Darrow (1957) for example, specifically discusses cortical monitors. Thatcher and John consider from their wide range of evidence that the concept of scanners is an attractive possibility and Giannitrapani (1971) has presented a particularly nice interpretation for alpha and beta. His results (discussed in more detail above) showed the characteristic decrease in alpha from diffuse to patterned light (the poster). To him this indicated "that alpha activity constitutes primarily a search for visual stimulation which decreases proportionately to the degree of structure of the stimulus". (p 144)

Remember firstly from the survey of literature on the hypnagogic state that alpha appeared correlated with awareness of the environment. Secondly, as we have rejected the sensory stimulus paradigm in favour of the direct perceptual systems approach, we may rephrase Giannitrapani to this effect. Alpha activity constitutes primarily a search for perceptual meaning in the physical environment, which decreases proportionally to the degree of structure of the field. When awareness of the environment is lost as in the hypnagogic state or when the environment is highly structured, alpha activity decreases. Alpha can be conceived therefore as the neurophysiological reflection of a scan for

invariants in the informational structure of the environment. When the field presents variances or uncertainties, alpha will be high. The more tightly structured the invariants in the field or in a perceptual task, the less the alpha scanner is required. Biologically, this makes excellent sense. Alpha as the dominant cortical rhythm must in some sense function to relate us to the continuing real environment. Alpha can be postulated then as a scan at the level of awareness or environmental vigilance. For the visual system with which alpha is intimately connected, the relevant carrier of structure is reflected light. But clearly our capacity for consciousness would, given the existence of scanners, require a scanning mechanism which operates at the level of awareness of awareness. Such a scan may be reflected in beta wave activity.

According to Giannitrapani, beta activity also indicates a search or scan mechanism, but one which "develops momentum only when diffuse stimulation is present. As the visual stimulus increases in structure beta activity decreases below the resting level." (p 144) "The beta effect observed appears when a stimulus needs an active participation (such as structuring) on the part of the observer." (p 145) Note that this beta response held for auditory as well as visual stimuli, showing that it is not only a visual system response. White noise was equivalent to diffused vision. Beta activity in the pre-frontal areas also increased while listening to a story and while performing mental arithmetic.

The phenomenon of spread of beta increase, noted in varying degrees in temporal, frontal and occipital lobes for all conditions, indicates "that beta activity is indeed a diffused scanning mechanism which originates or reaches the cortex in the temporal areas after the onset of a wide range

of stimuli" (Giannitrapani, 1971, p 144, emphasis is added). Laterality effects were also noted with a relatively greater involvement of the left temporal area (Wernicke and Broca sites) for the verbal task than for the noise condition. The prefontal areas appear to be involved not only in speech but more generally, auditory phenomena when "scanning for internal categories is required". (p 145) "Upon reduction of alpha activity consonant with onset of stimulation, beta activity increased." (p 145) He hypothesized that the beta scan will operate as long as there is a condition, either external or internal, which demands active structuring, and concluded that there is a hierarchy of scanners of which alpha is the first, high beta (21-33 c.p.s.) the second, and possibly another as yet undiscovered, even faster mechanism for more complex internal processes.

Giannitrapani's evidence is clear and his conclusions are in line with previous hypothesizing. In the conceptual famework adopted here, beta activity becomes the reflection of a scanning mechanism for invariants which operates over the whole set of directive correlations which constitute the material of consciousness, including the immediate perceptual field. But beta activity is not dependent on the presence of environmental awareness as is alpha. The beta scan will operate in states where awareness of the immediate field is lost. The question raised by Schacter's inability to attribute a significance to the presence of superimposed beta on the hypnagogic EEG is therefore answered. Hypnagogic 'old brain' rules of association, 'primary process thinking', operating freely over the set of directive correlations will demand a search for meaning and beta frequency will appear in the record.

Is this proposal congruent with other evidence? Beta 'bursts' were observed in a patient with deep-implanted frontal electrodes by Kamp et

al, (1972). The original situations in which they were observed included looking at projected slides of general interest, writing, drawing, etc conversation and interview, question and answers following electrical stimulation, word association tests and the period of a classical conditioning (contingent negative variation) paradigm. They were also recorded during reclining with eyes open or closed. This should not however lead the reader to the conclusion that beta bursts accompany mental relaxation or reduced intellectual processing. As has been pointed out (Gevins and Schaffer, 1980) EEG recording of such processes as 'imagining' cannot be behaviourally validated. The argument also works in reverse - there is no way of proving that mental work is <u>not</u> being done while the subject is ostensibly relaxing. Problem solving during sleep with the answer springing to consciousness early in the morning is commonly reported.

From detailed testing with the woman's cooperation, Kamp et al established the hypothesis that such beta bursts are associated with the brief release of a certain 'mental tension' built up over the preceding period occupied with attempting to predict the occurrence of the conditioning flash. From their during (beta bursts) to preceding (attempt to predict) ratios (p 261) it is clear that there was significant beta activity in the attempt to predict periods. As they point out "obviously, similar sudden brief release of 'tension' may take place also during mental processes inaccessible to the experimenter, for example during thinking" (p 265). In other words, periods of mental work such as predicting or thinking which are characterised by relatively high beta activity will be finalized with a beta burst after there has been a resolution of the purpose of the activity. That is, when the beta scanner is no longer (temporarily) needed. As was discussed above there

is no need to assume the existence of different processes or mechanisms when dealing with memorized and imagined material rather than a presently existent physical perceptual field. Kamp et al report that they were unsuccessful in recording this form of activity at scalp sites, but all other evidence indicates the phenomenon is one of normals. They also produced evidence (pages 260 and 262) that beta bursts habituate over time.

In two studies of different age groups, Vogel et al (1968) found a factor of 'automatization', a cognitive style which was inversely related to beta activity. Automatization refers to good performance on tasks which are simple and repetitive. Tasks on which good performances are inversely related to automatization, called 'perceptual-restructuring tasks', require inhibition of immediate responses to obvious attributes in favour of other attributes, in other words, scanning rather that focussing or fixating on a given structure. Their findings are consistent with previous literature and they conclude that "automatization, or habituation to a class of stimuli, then, should result in the disappearance of beta activity, since there is no longer need to reorient to that class" (p 173).

Similarly Gale et al (1975) found evidence that while variety in a stimulus effects gross alpha and the mid-alpha range, the upper-alpha and beta ranges were more affected by the number of stimulus characteristics. As we shall see this is totally consistent with an interpretation of the differential function of alpha and beta while watching TV. Their studies also bear significantly on the concept of recognition. Measures of EEG discrimination during inspection of the visual patterns presented to the S's related to subsequent capacity to recognize the patterns. "The more

stimuli are differentiated in terms of the EEG abundance, the more efficient is subsequent performance. Thus EEG changes which accompany variations in stimulus complexity are shown to have functional significance" (p 297). As we have seen above, there is little data indicating an active response to television while alpha remains relatively constant, and on these grounds alone we would expect recognition rather than recall to be the preferred mode. Part II contains this data.

There appears to be nothing in the literature that seriously questions the role of beta frequency in association with an active altering (Dustman et al, 1962, p 534) orienting-toward-meaning, disposition. These findings were further substantiated by Berkhout et al (1969) who considered that beta was the best discriminator between active, alerting and passive states, and that these were compatible with greater emotional significance (p 465). Berkhout et al specifically tie the patterns found to the "subjective perception of meaning" (p 468). Several studies have shown a decrease in beta activity from resting to test conditions in the laboratory but these test conditions may fall into those classes for which habituation is already established or likewise, as with television, have a deep rigid and repetitive structure such as many tests involving mental arithmetic which is conducive to rapid automatization.

The existence of two scanners, the operation of which overlap the perceptual field but which operate at the distinct levels of environmental awareness and total contents of consciousness allows us to postulate a range of states which vary in the proportions of alpha and beta. The following Table 13.3 summarizes the ways in which these could be expected to change.

Table 13.3 Changes in Alpha and Beta over Two Dimensions of Environmental Awareness (EA) and Structure of Relevant Field (SRF) in Normal Condition of Reflected Light

	EA	
	PRESENT	ABSENT
From Low to High	$\blacktriangledown\alpha \blacktriangledown\beta$	$\blacktriangledown\alpha \blacktriangledown\beta$
SRF (reflected light condition)	----------	----------
From High to Low	$\blacktriangle\alpha \blacktriangle\beta$	$\blacktriangledown\alpha \blacktriangle\beta$

When there is environmental awareness, alpha and beta will show concomitant changes as the structure of the field varies. But because when EA is absent, the reduction in alpha activity is likely to be more acute than it will be with a mere increase in rate of detection of invariants, the normal, everyday pattern can be expected to be a fluctuation of beta and alpha dominances. Moments of daydreaming with eyes open, for example, should show a relative dominance of beta. The Table fails to show a pattern of increasing alpha activity together with reducing beta. ($\blacktriangle\alpha \blacktriangledown\beta$) This would represent circumstances where EA is present but the perceptual field was diffusely structured, and where the beta scan has detected at some other level, a highly structured set of conditions. Because beta scan is not dependent on the visual system, such a circumstance could be represented by a radiant light condition where the light emitted is highly structured. For the alpha scan the perceptual environment will appear diffuse. But the beta scan may well be able to detect the nature of the signal. Moving into a radiant light condition where the light source is unstructured such as a Ganzfeld, we would expect increasing alpha and beta ($\blacktriangle\alpha \blacktriangle\beta$) which is the same pattern as that of moving from high to low structure in a reflected light condition.

We will explore the implications of this further, below. The critical point is that the beta scan may detect invariances of many types at levels other than those immediately available to the perceptual system (as in Chapter 12). Another such set of invariances could be those given by regularly sequenced or structured pheonomena such as the number system. For simple arithmetical or geometric exercises, the beta scan may respond selectively to the invariances themselves, interpreting either the number system or simple form, and any mechanical overlearnt operations as highly structured. In these cases, we would not expect to see large increases in beta activity. Again this is merely suggestive and needs discussion of detailed cases. At this point we note that two parameters are of critical importance to the relative appearances of alpha and/or beta activity, namely, awareness of the environment and the precise structural nature of relevant external or internal events. We may now attempt to interpret cortical theta activity within this framework.

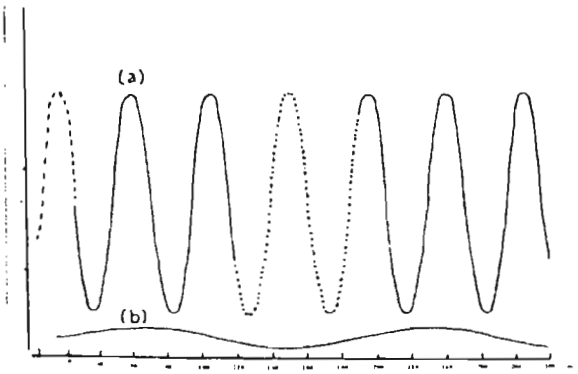
(ii) Theta As a Scanner

From the literature on the hypnagogic state, we noted that theta and alpha are inversely abundant and that the usual pattern is $\blacktriangle\theta \blacktriangledown\alpha \blacktriangle\beta$. From the EEG research into 'cognitive' functions we find that theta is often found with a range of patterns of increased or decreased alpha and/or beta. As these latter frequencies can be interpreted at the psychological level as scanners for meaning in the physical environment and in the total set of directive correlations, it is possible that theta too may represent or reflect another scanner. This was an early postulation which has been revived by Mizuki et al's (1980) discovery of a periodicity for frontal midline theta in the 63% of their subjects who showed this theta activity. No subject showed the phenomenon in the

first eleven seconds but after this beginning, S's who showed a high amount of Fmθ exhibited a relatively constant appearance while those who showed a low to moderate amount exhibited Fmθ in a periodic fashion. The periodicity appeared with an interval of 40-50 seconds, excluding one period from 120-190 seconds after the start of the task. Mizuki et al speculate that this periodicity consists of two components i.e. a relatively slow component with a cycle of 40-50 seconds and a very slow one with a cycle of about 160 seconds. Using a simple oscillation model they produced their Figure 4, reproduced here as Figure 13.2.

> "The curve shown in Fig. 4a could be considered to represent the cycle of appearance of Fmθ during the performance of a uniform mental task, namely attention for response to constant stimuli may possess the rhythm with a cycle of about 45 sec. The curve indicated in Fig. 4b could be considered to represent a more basic biological rhythm with a longer cycle of about 160 sec." (Mizuki et al, 1980, p 349, my emphasis)

Figure 13.2 Periodicity of Frontal Midline Theta during Mental Arithmetic (From Mizuki et al, 1980, p 349)



"The calculated periodicity in appearance of Fmθ , according to a simple oscillation model, consists of two components, indicated as (a) and (b). The dotted lines show epochs where Fmθ was not observed (initial part) or markedly reduced (intermediate part)."

Their conclusion was that there might exist some periodicity of an attention mechanism. As we have seen from our survey this conclusion certainly agrees with the overall trend of results, and the conclusion above that the appearance of theta signals a breakdown in ecological perception. I propose therefore, that as alpha and beta activity may represent scanners, theta may also reflect a scanner which comes into play when either the alpha or beta scans or both in combination, have moved outside the normal waking adaptive limits by virtue of either an internal or external inhibition. This may be for example, a peaking of the circadian cycle or the presence of a particular environmental feature or event which inhibits normal functioning of the two predominant scanners. Theta is, therefore, in the waking state, an intrusion of primary process into the everyday secondary process world through the action of a sub-cortical scanner, generated most probably within the hippocampus. (Bennet, 1977) For the hypnagogic state, the appearance of theta follows the alpha decrement while the beta scanner operates over the total set of directive correlations giving the characteristic $\blacktriangle\theta\blacktriangledown\alpha\blacktriangle\beta$ pattern.

Theta's more frequent appearance in childhood is also covered here, as only gradually does the cortex grows to maximal control in biological maturity. Theta activity can be understood in the waking state, therefore, as a return to a more immature level of function in conditions which produce stress or distress for the normal ecological mechanisms of adaptation. Tomkins' (1963) slow gradient of distress fits data such as Mizuki et al's eleven second gap between beginning of task and appearance of theta, and the noted delay in appearance of theta following the decline of alpha at onset of the hynagogic state.

The original interpretation of theta appearance as reflecting a scanner for pleasure or pain may well have been at least partially correct. In the adult waking state, its appearance will tend to follow any ecologically unusual combination of alpha or beta activity where 'ecologically unusual' covers objects or events not found in nature such as the number system, alphabetic symbols, geometric patterns, radiant light signals, etc. These are highly structured, yet to the evolved human nervous system will appear meaningless with consequent reduction in arousal as was shown by Cooper et al (1966). Depending on the precise nature of these objects or events and the extent to which the person is forced to attend to, concentrate on and make meaning of them, the patterning of theta, alpha and beta will vary. To the extent that we can specify their precise nature and the degree of attention required and consequent reduction of environmental vigilance so we should be able to predict the pattern which will appear. Remembering that a scale of meaningfulness was found by Phelps et al (1981) and Engel (1980) as well as Cooper et al (1966) we can hypothesize that the patterns will at times change along the following scale.

Figure 13.3 Relation of Theta Scanner to Alpha and Beta Scanners. Information and Learning.

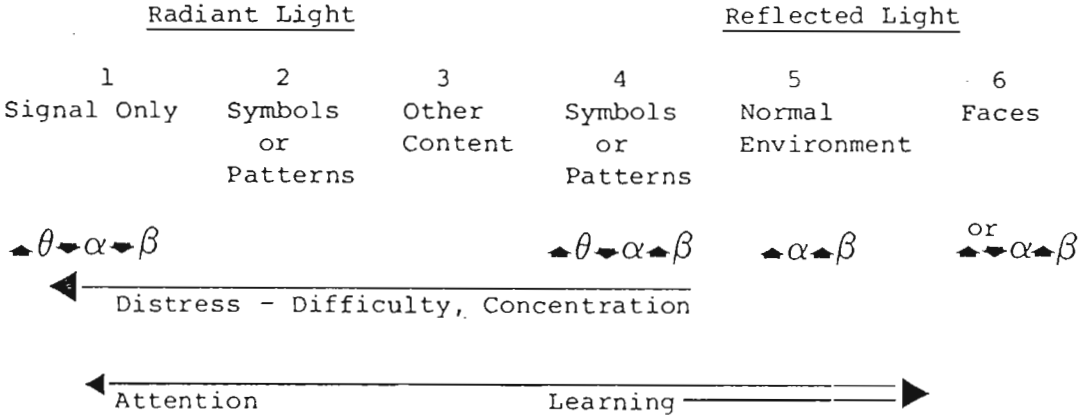


Figure 13.3 summarizes one of the complex set of relations expressed by the EEG, that called the 'cortical distress scale' where theta arises in combination with a decrement in beta. As the beta scanner's response is progressively reduced as the environment moves along the scale from right to left presenting greater structure, and alpha will vary for reasons discussed above so the theta scanner will come into play.

The overall patterning of the three will represent the effort to maintain an optimal cortical firing rate such that the intrusion of the theta scanner will provide material for the beta scanner to work on. Over time, and if the environment is conducive, the pattern will evolve into high theta low alpha and high beta which is the hypnagogic pattern. It is also that most commonly found in cognitive testing covering 26% of the cases (Table 13.1).

As some subjects have been aware of the distressful nature of the high theta, low beta pattern, the figure also expresses the relation of the patterns to the affect system such that learning is at the far and opposite end of the distress scale, i.e., it is related to the normal evolutionary scanning of ecosystem and total set of directive correlations which is likely to be experienced as more positive. Brown (1971) found however a mixture of positive and negative affect associated with high beta activity, but excitement was specifically noted. Presumably also as the far left pattern becomes over time closer to that of the hypnagogic state, there will also be a move towards a more positive affectual state. From descriptions of the hypnagogic state the affect appears to be that of enjoyment, 'floating'.

Given that the EEG is in a constant state of flux reflecting the sensitivity of the CNS to momentary conditions and that these patter represent statistical entities gathered over a period of time, we can extract three major configurations of relevance. Table 13.4 contains these.

Table 13.4 Three Major Patterns of Scanning Activity.

	θ	α	β	Incidence from table
Normal waking, Learning.	▼	▼ or ▲	▲	18%
Concentrated Attention, Television	▲	▼	▼	22%
Drowsy, Hypnagogic	▲	▼	▲	26%

				66%

The incidence figures here taken from the summary of the literature reflect firstly the unusual nature of the testing situation. From Sim et al's (1977) work we know that the majority of the waking day is spent in an alert state of environmental interaction which would correspond to the first pattern. Secondly, the fact that 26% of the cases fitted the hypnagogic pattern does not mean that the full range of hypnagogic phenomena was present, although perhaps over a more substantial duration some of these may have appeared, as happens with some forms of meditation or training. It does, however, indicate that for some people, performing such a set of tasks or activities requires a special effort which in terms of the EEG is similar to if not identical with such an altered state of consciousness.

This interpretation fits nicely with Vogel et al's (1968) postulate of two classes of inhibition. "Class I inhibition would refer to a gr inactivation of an entire excitatory process which results in the

conduction of a relaxed, less active behavioural state, as in sleep, or as in the inhibition of previously learned behavioural acts... Class II inhibition would refer to a selective inactivation of particular responses so that a continuing excitatory state becomes directed or patterned, as in the facilitation through practice of a behavioural act to the point that the act becomes over-learned or automatized (p 172). Class I in terms used here would represent the activity of the theta scanner when the activity of both the alpha and beta scanners was reduced. Class II would represent the theta scanner in action when the activity of only one of the other scanners had been reduced, allowing for either some continuing environmental vigilance or extraction of meaning.

Before we conclude this section by re-examining television in the light of this discussion, there were found two other patterns of interest here. They are those associated with an increase or decrease of all three of the frequency bands reviewed here. The first is the prelaunch pattern described by Adey et al (1967) (included in Table 13.2). This was characterized by high theta joined by increasing alpha and beta. Adey et al emphasize the highly novel and stressful nature of this event and it is possible that in such extreme circumstances, all scanners must operate rather than fluctuate in various oppositions. The ten percent of cases found which were characterized by a decrease in these three frequency bands, therefore, present something of a problem, as we would expect a very low level of arousal to show some increased theta wave activity. It is possible, however, that as Giannitrapani suggested, there are other scanners which correspond to both faster and slower frequencies. Delta, as has been noted, behaves differently from theta. Activity to maintain an optimal cortical firing rate may have been taking place at frequencies which were not measured.

In summary here, an argument can be made for the existence of a theta scanner which allows some coherence to be made of the various EEG patterns displayed by the functioning human system. In discussion it has become clear that much of the early work done on theta wave activity drew conclusions which have been validated here.

5. Television and the Scanners

Implications for the television hypothesis are quite clear. The almost totally consistent failure of testing to elicit significant quantities of beta activity while theta is significantly present during television viewing can be interpreted in terms of its highly structured nature. The beta scanner for structure of meaning appears in a state of reduced activity. But the 'pictures', the content of television, do not differ in their degree of structure from those in a projected, ambient light cinema presentation. The excessive degree must therefore be given by nature of the medium, the radiant signal. Once this highly structured and repetitive stimulus is detected, lets say in something between 20 seconds (Walker, 1980) and 30 seconds (Krugman, 1970), the beta scanner is no longer necessary. The alpha scanner may continue to search at the level of the moving pictures, or content, although some reduction in alpha activity should be expected. As Gibson has pointed out (1966) moving pictures do convey more information than the still, which may account for some fluctuation and reduction of alpha activity. Empirical data in Chapter 11 shows this effect to be mainly non-significant. Increased activity by the theta scanner can therefore be expected, producing the pattern for concentrated, narrow attention found in the cognitive tests.

As reading from TV will require more concentrated attention and therefore the appearance of more theta than while watching pictures we would expect less alpha with reading than with pictures. Checking back on Silberstein et al's (1983) data, we find this was the case (Table 13.5).

Table 13.5 Means for Theta, Alpha and Beta Activity in Text and Non-Text Conditions (from Silberstein et al 1983, p 19)

	Non-Text	Text	Percent Change
Theta	23.20	29.45	26.9% ↑
Alpha	20.48	18.23	11.0% ↓
Beta	18.08	17.03	5.81% ↓

Theta activity did increase from Non-Text (pictures) to Text (reading) while alpha and beta both decreased. But the mean differences are not significant.

Should viewing continue for extended periods however, the scanner pattern may move closer to that of the drowsy hypnagogic, with some beta activity superimposed. But the beta scanner will be then searching for meaning within the primary process thinking thrown up by the augmented theta activity and this may not be amenable or available to conscious perusal. Television then becomes a subliminal technology whose content is absorbed into, and will influence the ongoing sub-cortical primary process. In this sense television ceases to be an environmental event and becomes an all encompassing evironment in its own right. Real environment is replaced by television and environmental events are replaced by internal processes. Television can therefore be conceived as an econiche.

Such an explanation in terms of differential scanners successfully integrates the habituation and radiant VS reflected arms of the hypothesis. By definition, the true natue of the radiant light signal is

more rigidly and repetitively structured than in the pattern given by ambient light bouncing off surfaces, colours and textures. Detection of structure will be faster in the case of a radiant signal and to the extent that it is unvarying, it will become habituated more strongly. While it is easy to recover from boredom of a view because of the changes in information conveyed by the changing light and shadows, it will be more difficult to recover from an initial habituation to a radiant signal whose total structure or informational content can be scanned and detected almost immediately. This construction fits the evidence surveyed above, particularly that of Silberstein et al.

Theta and the Case for Television as a Maladaptive Technology

In this part III we have surveyed the effects of television at the short-term perceptuomotor level of adaptation. Through chapters 12 and 13 it has become clear that there is a range of reaction to the technology at this level. Apart from the evidence which indicts television as an epileptogenic stimulus for some normals, this current chapter has reviewed both direct and indirect data bearing on the degree of normality of theta abundance in adults.

Indirect evidence that substantial appearances of theta in waking adults constitutes a 'mild abnormality' or 'pattern of clinical interest' centres around its incidence, and the notion of individual differences in sensitivity or vulnerability to extraordinary stimulation. The wide range of individual differences in the elicitation of theta are mentioned by almost every author, and this is certainly one of its most distinguishing features. From the early studies reviewed above, which directly cited this characteristic as evidence for a genetic or basic personality weakness or susceptibility to today, the picture has not

changed. Mundy-Castle reported only 10% who showed theta while Ishihara and Yoshi (1972) had to eliminate 31% of their sample because of lack of observed theta. Overall, alpha and beta display a stability of appearance and performance relative to theta which as we have seen indicates theta's role as a key index of the nature of the relation between system and environment. After surveying various incidences reported, particularly of frontal midline theta, Palmer (1976) concluded that even the highest (21%) did not render this rhythm a perfectly normal pattern. Recalling Jeavons and Harding's hypothesis of the involvement of a genetic factor in photosensitivity we can expect different populations to show different incident rates. Chapter 4 assesses the evidence for such an underlying genetic or personality factor. Theta has also been proven to be more difficult than alpha or beta to induce in laboratory studies. Yet some people show theta appearance almost immediately after the introduction of a patterned or repeated environmental event. Work done on hypnosis (Schacher, 1977) clearly implicates theta in a factor of <u>susceptibility</u> and it is with this phenomenon that we find the link with the kindling model and epilepsy. My conclusion then must be that the significant appearance of theta in the adult waking state <u>is</u> a mildly abnormal response of those who are particularly sensitive to deviations occurring in the normal perceptual field in which we have evolved.

The theta that has been observed to occur during all the conditions reviewed here is simply the more normal than epileptic, or a precursor response to a maladaptive stimulus. For any given population, we would see then a continuum from convulsive activity through large to diminishing percentages of theta, to normal alert waking mode. If such a continuum were to be normally distributed the most common response to

television would be the elicitation of a significantly theta state. Chapter 11 contains the evidence supporting this.

Our data review allows us to derive a scale as follows:

Range of Response to Ecologically Deviant Features or Events.

1. Normal Response - no theta.
2. Some theta showing periodicity
3. Abundant constant theta, approaching drowsy or hypnagogic pattern
4. Epileptic spike and wave response, may be subdivided at least into
   (a) petit mal
   (b) grand mal

Within the conceptual framework adopted here it is obvious that on two grounds television must be judged as a maladaptive technology, that is as one which:

(i) produces a range of reaction which cannot satisfy the focal condition of a directive correlation. In any environment, television becomes an econiche Ek=0 such that the response function P(Yo)=Ek is not matched by the response function B(Yo)=Hk. Hk is a range of responses each of which has been shown to be a different system state such that Hk=0-4, at least. The focal condition F (Ek; Hk; Hl,k; H2,k; H3,k; H4,k)=0. On this ground alone we may conclude that television is a maladaptive technology.

(ii) Inhibits consciousness and purposeful behaviour. The data we have reviewed from direct testing of television's neurophysiological effects, its role in the production of epilepsy and the significance of theta wave activity, all support this conclusion. From the 'locking into' response to the meaningless radiant light signal, the

> lowered activity of the alpha and beta scans reflecting reduced environmental vigilance and good housekeeping of the contents of consciousness, etc, to the noted distortions of various forms of perception and behaviour, we must conclude that television is maladaptive because the awareness or behaviour it most commonly produces is goal-seeking but not purposeful. (Emery and Emery, 1976). It thus reduces the probability that consciousness will occur.

This is sufficient to conclude the case against television at the perceptuomotor level of adapation. But there is also, as we have seen, some evidence of maladaptation in the sense that watching television will have effects that extend further than the back-reference period. The support gained for the habituation hypothesis and the kindling model of epilepsy, which are both learning phenomena over the medium- rather than the short-term period of adaptation, shows that the effects of television cannot be confined within the back-reference period of its effects at the perceptuomotor level. The maladaptivity of this technology can be considered proven on each of these grounds. As we have seen in Part II, the evidence at the medium-term, learning level of adaptation mirrors the conclusions drawn here.

But another quite specific convergence emerges from this data; the relation between theta activity, knowing 'of' and recognition. Our analysis of knowing 'of' showed that it was an ecologically incomplete response or mapping function, defined only over the systems arm of the directive correlation. It may be elicited only by the primitive (pre-language and consciousness) function of recognition. In this chapter, it has been argued that an increase in theta represents a

breakdown in the directive correlation between person and environment in the sense that environmental vigilance is neglected. In other words, theta wave activity is the perceptuomotor expression of knowing 'of'. At the holistic level, we have a coordinated systemic response to television such that we can confidently predict that as theta increases during viewing, there will be at the ontogenetic level, a corresponding increase only in knowing 'of' and not knowing. As theta increases, so will the need for tests of recognition. The remaining task at this perceptuomotor level is to check these conclusions by examining other members of the CRT family.

Chapter 14 Other CRT Technologies (VDU's), Sensitivities & The Ecological System

Chapter 13 examined levels of neurophysiological response, other than normal or epileptic, to radiant light, flicker and other deviant stimuli. We concluded from this review that television as a technology could indeed be labelled maladaptive. We need now to establish whether other members of the CRT family present a similar range of response allowing for the fact that different members have slightly varying technological characteristics. Next to domestic television sets, the most ubiquitous member is the video display unit (V.D.U.) found in a range of applications from word processors to video games. That the VDU is potentially epileptogenic has been established (Chapter 12) and further confirmation has been provided by the Medical Research Council unit at Cambridge (Colover & Warr, 1979).

From the immediately previous chapter however, we would expect that a more common response will take the form of the 'mildly abnormal' thereby expressing a sensitivity to one or more of the CRT's unique features. Increasingly, research is justifying this expectation. Such research however, has also implicated another dimension of sensitivity associated with CRT technologies, including television per se. In explicating this additional focus of debate we are forced to reconsider the ecological nature of the human being. This chapter therefore falls into two major parts: responses to video display units, and a look at the new evidence of our sensitivity, at the perceptuomotor level, to other physical dimensions of the eco-system. It does not aim to be exhaustive, serving only as check point and preview of new directions. When considering the reported effects of VDUs however, there is virtually no need to be

comprehensive as there are no conflicting reports of evidence. To be sure, there are varying rates of incidence but no findings of 'no effects'.

1. Video Display Units -- A Separate Problem?

Video display units or terminals (VDUs and VDTs) have finally begun to receive some official scrutiny as a public health hazard. A recent study (Frank, 1983) has prompted the USA Congress to investigate further the convergence of widespread complaints by users and the confirmation by researchers that there are real differences in health between users and non-users (Philadelphia Inquirer, 1983). Previous studies such as those in the special issue of Human Factors (Bhise et al, 1981) appeared to excite little attention. But unlike domestic television, problems with VDUs touch directly upon the economy, providing a more urgent incentive to research and action. While the focuses of concern are not as dramatic as epilepsy, Frank's finding that the amount of time lost from work for medical reasons is greater for users than non-users shows that they are obviously costly. Frank's results confirm those of Shephard (1971) quoted by Warr (1981). Management will be looking more closely in the future, and the Australian Public Service Board has acted promptly in setting up a task force into the current epidemic of 'repetition strain injury' or RSI, previously called 'tenosinovitus'.

Needless to say VDUs have not lived up to their early promise. Early advertisements promised that one word processor could replace six typists. Two to three would appear closer to the reality (Warr, 1981, p 531). As Frank notes in his introduction

> "Prior to their introduction, one might have predicted that workplace and other exposure to this equipment would involve large numbers of individuals, and in view of the potential

> public health significance, some questions might have been raised with regard to health effects. As a review of the literature and a historical perspective on the introduction of new technologies indicate, little research had been done. It took the concerns of users to direct attention to the potential problems associated with operation of this equipment." (1983, p 1)

As we shall see below this was not simply a refusal to consider that we may not be adapted to such a technology: there has been censorship of research results and punishment of those who refused to accept this. Some of this data has only recently been made public (Kuhns, 1982). It is at this point that we must broaden the range of factors associated with the CRT technology. Light and our sensitivity to it is one dimension, but VDU research has also brought to public attention another - extremely low frequency non-ionized radiation.

(i) Similarities and Differences between Domestic TV and VDUs

These are essentially identical technologies; the VDU is simply a computerized typewriter with a TV display screen. They share radiant characteristics in both the visible and invisible spectra of electromagnetic energy, a flickering and pattern of visible light as discussed in relation to epilepsy and the same legal standards for emissions. Both radiate frequencies from almost the entire electromagnetic spectrum, ionizing and non-ionizing alike, although as DeMatteo et al point out, recent developments in physics have shown this distinction to be quite arbitrary (1981, p 11).

There are a few minor differences. While both produce pulsed or modulated fields, the pulse generators in VDUs are likely to be stronger in order to achieve a greater clarity or readout for text and numerical material. But this varies across manufacturers (Kuhns, personal communication). Related to this is the 'refreshrate' which in the UK is

at least 50 Hz in contrast to the 25 Hz for domestic TV sets. Flicker should therefore be less of a problem (Gilbert, 1978) but as we saw above, flicker does not have to enter awareness for it to have an effect. VDUs often employ slower phosphors which reduce the depth of modulation of the flicker and many do not use a system of line interface. Wilkins et al's (1979) worry that information services broadcast via domestic TV sets which do not possess these advantages would result in an epidemic of epilepsy emphasized as did other studies, the role of distance from the set.

Of all the slight variations in CRT technologies, operating distance is by far the first and foremost difference. The critical difference between watching TV and operating a VDU, playing a video game or solving a problem on your personal computer, is that in the latter instances you must be within close range of the device and its radiant field. If the literature on VDUs is to be a check on the results of television research it should show not only the same range of results but there should be a bunching of mildly abnormal responses towards the normal end of the scale. As radiant effects will reduce in effectiveness with distance from the source, even the least sensitive amongst us should be expected to show a more frequent of widespread maladaptive response to the close-up CRT technologies than to television as normal domestic entertaining viewing. Effects of VDUs therefore should represent a more extreme case than television, in the sense that although the ends of the scale -- no maladaptive response and epilepto-convulsive response -- are set, the manifestation of mildly abnormal reactions should be markedly higher.

(ii) VDUs: A Real Problem

In the most recent survey, done in cooperation with the Newspaper Guild at six sites across USA and Canada, Frank (1983) found significant differences between VDU users and non-users on the following items ranked in order of statistical significance:

Table 14.1 Health Differences between VDU users & Non-users

Trouble getting up)	
Eye Strain)	
Eye irritation)	p = .0001
Blurred vision)	
Shoulder pains)	
Neck pains	p = .0002
Trouble sleeping	p = .0004
Red eyes	p = .0005
Being irritable	p = .0006
Frontal Headache)	
Low Back Pains)	p = .0008
Worse vision	p = .0024
Headaches	p = .004
Have more energy	p = .04 (reported by non-VDU users)

Frank's data was insufficient to test the incidence of reproductive problems, birth defects, miscarriages etc., or cataracts. He recommends that these disorders plus skin rashes and effects upon spermatogenesis, should be further investigated.

While other studies report various details or additions to this basic list, such as changes in colour vision, dizziness and nausea, slower reaction times, rheumatic and asthenopic disorders (L'aubli et al, 1982, abstract only), it is noteworthy that not one single article has failed to find the hard core of basic symptoms. This is circumstantial evidence at an overwhelming level. Ostberg (1975) estimated that at least 40% of clerical users find 60Hz CRT flicker uncomfortable in the long run, and the problem is exacerbated when screens are cluttered with information

and when several screens can be seen at the same time. These operators are exposed to a flickering field. This has also been discussed by Slesin (in Kuhns, 1982, p 14).

In distinction to reading hard copy, reading from CRTs is eased by lower levels of ambient light (Ostberg, 1975), closer to 150 lux than the normal 500 lux (Colover & Warr, 1979). This is consistent with most recent conclusions by TV epilepsy researchers.

L'aubli et al (1980, abstract only) studied four groups of office task, data entry terminals, conversational terminals, traditional office work and typing:

> "Eye impairments are observed in every group of office employees but the impairments are more frequent in VDU operators. Th impairments persist during leisure time. High luminance contrasts between screen and source document are associated with an increase of eye troubles. Increased oscillating luminance of characters is associated with lower visual acuity, with a higher incidence of subjective and objective symptoms of eye irritation including more frequent use of eye drops."

Newspapers and magazines have generally taken the view that there is problem (Knox, 1983) and the Europeans acknowledged it long before the USA by attempting to design out ergonomic and some lighting problems (New Scientist, 1983; CPT, 1983). They also instituted standards which limited VDU operation to two hours at a time, followed by a one hour break. This followed their observations that it takes about two hours for common symptoms to appear (Beal, 1982, p 61).

With some initiative, two students surveyed twenty-six of their peers in sixth grade

> "They know that it can be hazardous to their health and education. They gave reasons such as blisters, blurry eyes, poor hearing,

nervousness, lateness, missing school and not thinking about their work."

These students also considered the videos addictive, with boys more prone than girls, and stressed that this was not a question of escaping from their problems. (Baughan & Radano, 1983, my emphasis)

Bolson (1981) working from Ostberg's measurement of air traffic controller's vision after two hours at a screen where he found an error of one-half diopters when the eyes attempted to focus on near and far objects, concluded that the possibility of long-term visual deterioration could not be ruled out.

There can be little doubt about long term damage to visual perception. A study by the French Institute of Health initially screened out all Air France VDU operators with eye troubles. After a year's further VDU use, the remaining visually perfect 216 operators were tested. "Ten percent had some sort of eye trouble and nearly all suffered from visual fatigue." Symptoms included all those noted above, plus short-sightedness (from Colover & Warr, 1979, p 369; Warr, 1981) One interesting observation comes from Meilach (1983, p 52): "a person becomes so involved with the word and number play, he (sic) doesn't realize that an overhead light fixture, a sunlight-flooded window, or perhaps a white shirt are being reflected in the screen." The screen induces the high attention, low vigilance noted above with TV and task-orientation, but probably to a higher degree.

From the operator's viewpoint the main problem is "flashing messages which appeared across the VDU screen", described as "most exhausting" (Timbs, 1978, p 363). Others have felt "their eyes are glazing over after a few hours at the VDU. Staring intently at the screen is

extremely tiring and concentration becomes increasingly difficult". (Colover & Warr, 1979, p 370)

Chronic fatigue is certainly the most difficult symptom to isolate but is known to induce headaches, dizziness, indigestion, depression and nervousness (Colover & Warr, 1979) and together with reduced periods of concentration, these have been referred to as the second-order effects. They are systemic and behavioural and not directly correctable (Warr, 1981)

The study reported by Stammerjohn et al (1981) showed that results cannot be explained simply by surrounding ergonomic or physical lighting conditions. The most bothersome design features were found to be in order: glare off screen, character brightness, readability, flicker and screen brightness, and these were most highly correlated with musculoskeletal, visual function and emotional or mood complaints. They found no significant relationships between these factors and psychosomatic complaints, but the difference between these and affectual complaints is not explained. But factors such as keyboard and screen height were frequently found to be nonoptimal and yet showed little or no relation to somatic complaints. Adjusting these would have made little difference. Indeed, all known ergonomic factors have been rectified in some Toronto work sites, but the problems remain. (Personal communication with Canadian unions, 1984)

Key factors are those pertaining to the radiant luminant nature of the technology itself. Dainoff et al (1981) concluded similarly: "There appear to be two essentially separate groups of individuals. One group tends to report relatively high levels of job pressure and job fatigue.

The second group (who seem to spend a relatively larger portion of their workday looking at the VDT screen) reports high levels of visual fatigue and VDT-related lighting problems. General symptoms of physical and mental stress appear in each of these groups, as suggested above, but probably more in the second group. The second group is also larger than the first ... It does ... seem to be fairly clear that the preponderance of visual symptoms among VDT operators in this sample cannot be explained by non-visual aspects of the job." (p 436)

Smith et al (1981) found that a good many of the stress problems they identified could be traced to the job content, or more correctly put, their clerical VDU operators suffered from low levels of the six requirements for psychologically satisfying work. (Emery & Emery 1974, Emery & Thorsrud 1977) The relation of these to health has been established (O'Toole, 1974). The more specific types of health complaints voiced were, however, indicative of special problems associated with the visual nature of the technology. Thus, they recommend both job and workplace redesign. We must note however that redesigning the physical workplace while leaving VDU technology as is, does not appear on current evidence to have a high probable success rate in solving the visual and more general health problems. These are problems intrinsic to the CRT technology.

In the face of this widespread consistency of symptomatology, there have been the normal cautious disclaimers and refusals to confront the evidence. Lack of awareness of the differential response to radiant and reflected light has lead to statements such as "Careful studies ... indicate that the task is, in fact, no more demanding than a typewriter" (Voke, 1980, p 561). Rosenthal & Grundy, as late as 1979, concluded

optimistically that the mental concentration and unfamiliar use of the eyes must be expected to cause eyestrain, but this will disappear when familiarity with the work allows the operative to relax. Marshall (1981) noted that there were lots of 'minor' effects. As recently as 1982, Lamer was still insisting that no reported instance of disease has been shown to be caused by CRTs, and that such complaints as fatigue are difficult to assess objectively. This is of course illustrative of the extremes of the scientific paradigm.

Ergonomic factors and anxiety have been cited as the main factors behind the reduced motivational, distress syndrome of effects. (Update, 1983 quoting a study released by Wright Line). Meilach (1983) began her article "Ergonomics ... the Science of Safe Computer Use" with a discussion of 'computeritis' for which psychiatrists and psychologists are recommending a change of 'mental attitudes.' Certain personality types are hypothesized as attracted to the computer - cautious, weak on relationship skills and not very assertive, in other words the traditional American recipe for distress. This profile is supposed to explain the absenteeism and high annual turnover rate of 25-50% in data processing, while quoting a range of government and medical sources to the effect that there are no long-term or serious effects. She does however acknowledge a problem with eyestrain which she claims can be fixed by reducing or eliminating glare.

This 'subjective hypothesis' or resort to blaming pre-existing pathologies has been criticized and rejected by Warr (1981). He also joins many others in decrying the 'complacency' of the scientific establishment in the matter of standards for radiation emission. Official studies such as that of Murray et al (1981) continue to conclude

that operators are not at risk because levels of radiation and industrial contaminants are below the standards, without discussing the adequacy of the standards themselves. The problems are intertwined-because it has been already defined as a non-problem, there is no problem and secondly, even though there is a problem there is no known scientifically established mechanism. In 1975 Ostberg noted that "It has not been possible to trace the origin of this discomfort (or pain, at higher levels of glare) in spite of 75 years of investigations." (p 26)

It is fair to say that the VDU phenomenon presented the scientific community (in the large, certainly not entirely) with a mystery and one that it was simply not equipped, conceptually or attitudinally, to deal with. Referring to the 'epidemic' of complaints about VDUs, Gunby (1981) pointed out that fluorescent lamps emit more visible and ultraviolet light, space heaters give off more infrared radiation and TV emits more x-irradiation. Crespy et al (1980, abstract only) like many others, simply called for more research.

By emphasizing that ophthalmologists should cooperate with many related disciplines, Mert'e (1982 , abstract only) may have opened the way to overcoming some of these problems caused by lack of awareness of critical factors. The convergences are there, if people are prepared to look outside their disciplines for them. For example, Warr's (1981) discussion of possible theories to explain the consistent symptoms of distress noted with operators has marked similarities with the theta phenomenon or mildly abnormal neurophysiological response. In particular, he notes performing a monotonous task in a uniform environment, filtering out external events and attending only to internal events and those directly related to the task, and reduction of chances

for human interaction leading to a higher subjective incidence of fatigue, muscle ache and irritability (p 536). He also quotes a study of the curvilinear relation between flash rate and response in the optical cortex of cats, which is supportive of data reviewed here in previous chapters.

We may now compare this picture with the predictions made by Emery & Emery (1976) and the conclusions of the previous three chapters, all of which to this point have concerned themselves with only the visible range of the electromagnetic spectrum.

From their logical argument about the function of the human perceptual, and more generally central nervous system, Emery & Emery concluded that while television may reward, it cannot motivate (1976, p 94) Viewing results in muscle relaxation and/or sleep. Over time this would result in a generalized state of fatigue, lowered motivation and purposefulness (dissociation) which would, however, be interspersed with periods of impulsivity and/or aggression. For particularly sensitive viewers or over long periods, symptoms reminiscent of quite distinct pathologies may be observed. Correspondencies between these predictions and the reported complaints of VDU users are obvious; fatigue, low energy and motivation, irritability and a general reduction of feelings of well-being, and some symptoms sufficiently specific to qualify as somatic health problems requiring time off work and medical intervention.

Consider now the VDU operator in terms of the theta scanner. For sensitive individuals it was shown that tasks or situations requiring, or conducive to, concentrated or narrowly focused attention will result in a mildly abnormal response which is experienced as distressful. Operating

as such close distances, a radiant light screen with its attendant repetitive signal magnifies the effects of both watching television and manipulating symbols such as numbers or letters in a reflected light condition. VDU operation combines the worst of the two worlds:

(a) the difficulty of extracting meaning from radiant light and habituating to its signal and the
(b) ecologically unnatural nature of the task characteristics with additionally,
(c) the absolute necessity to perform to specified levels of quantity and quality

We would expect from this overview that even minimally sensitive people would show greater deleterious reaction to VDU use than to watching TV or solving 'cognitive' tests in a laboratory. Indeed the incidence of disorders associated with VDU operators is elevated above the incidence of theta reported in the previous chapter. Seventy-five percent of all users appear to be affected. (Fortin, in Kuhns, 1982, p 2) As DeMatteo et al point out "working at a VDT is equivalent to holding your face about 18 inches from your television screen several hours a day, five days a week." (1981, p 6) Distance as was noted in the epilepsy chapter is critical. It may be as, if not more, critical in the matter of non-visible than the visible spectrum, the former of which is DeMatteo et al's particular concern.

U.S. studies have confirmed European findings over the whole range of symptoms and the centrality of stress (distress). (Tomkins, Vol II, 1963) Bergman also accepted the operators' belief that their work had had "severe impact" on their health (1980, p 26). He concludes "no other factor in the work environment--not indeed, all others combined--has ever created such a torrent of health complaints and problems as have VDTs" (p 26, added emphasis)

2. The Effects of the Invisible Radiation Spectrum

As Frank (1983) and others note, early concern with regard to VDUs was related to radiation exposure in the frequency ranges on either side of the visible spectrum, rather than from any relation to the effects of television. These were at the time unknown or only hinted at in psychosocial research (Himmelweit, 1958). Concern in this area has not abated; in fact it is a burgeoning area of new research with far-reaching implications for our perspective on ourselves as creatures of the planet Earth and our inbuilt sensitivities and effectivities. The following paragraphs make clear the fact that the previous discussion and conclusions about the effects of television within the visible frequencies range is but a segment of the debate that is needed around the question of maladaptivity of these new technologies. The overall picture of TV and VDU in terms of radiated energy is shown in Figure 14.1. (taken from DeMatteo et al, 1981, p 10) (For a more detailed breakdown, see Appendix to this chapter.)

Figure 14.1.
ELECTROMAGNETIC SPECTRUM

Non-ionizing radiation					Ionizing Radiation		
Radio frequency (Hertzian Waves)					X-rays and Gamma rays		
Extra low Frequency	Radio frequencies	Micro-waves	Infrared	VISIBLE LIGHT	Ultra-violet	Soft X-ray	Hard X-ray | Gamma Rays
Hydro lines VDT	radio, CB, TV VDT	radar micro-wave ovens	Sun VDT		sun VDT	medical X-ray TV VDT	nuclear fall out
Low Frequency							High Frequency

NOTE: *Static electric* and *magnetic fields* do not travel in wave form and do not radiate energy. Static fields will be discussed in more detail later.

CRT technology clearly produces radiation across a majority of the spectrum. Early research focused on ionizing radiation as it was commonly held that low frequency waves could not damage human tissue. In theory, VDUs are designed to contain ionizing radiation but in Canada the safety standards are set for TV and assume a viewing distance and brief duration of time. As DeMatteo et al argue, new evidence that radiation effects are cumulative and the risk of damage is greater with repeated low doses than with occasional high doses, has forced the regulatory bodies into an approach which is unacceptable in any other sphere; a recognition "that there are no safe levels for radiation exposure, but that some adverse health effects are socially acceptable." (DeMatteo et al, 1981, p 15) Additionally they note that individual machines are not tested for leakage as they come off the assembly line and official studies found up to 8% give off high levels of x-rays.

Standards have been set also for the differing types of non-ionizing radiation with the exception of extra-low frequency(ELF). Based primarily on the power of the energy to heat body tissue, these standards ignore the fact that non-thermal effects can cause electrical disruption in cells, that there are individual differences in rate of absorption and that the eyes, reproductive organs and brain absorb faster than other parts of the body. The Canadian standards for occupational exposure are set to a level 100 times higher than that permitted in USSR. Marha has shown that the repetition of 1000 Hz signal (within the microwave band) kills rats within three to four minutes. This corroborates other work which has shown that pulsed fields are more effective than continuous wave operation (DeMatteo et al, 1981, p 22; Knox, 1983) The ultraviolet spectrum is more commonly understood as it is responsible for sunburn,

eye irritation and burns on the cornea, with the delayed or chronic effects of skin cancer and cataracts.

The emphasis above on the non-visible spectrum and reproductive organs supplements the discussion in chapter 11 of the relation between visible light, melatonin and reproductive difficulties alleged with CRT use. These two leads require urgent investigation.

3. Extra-Low Frequencies (ELF) and Total System Function

ELF frequencies range from 1-100 Hz. It is about this range that new and exciting discoveries have been made and bitter disputes fought. Probably the most common source of ELF is the grid of power transmission lines. Extended space will be devoted here to this area of research because as will become more obvious below, it demonstrates most precisely th system-in-environment properties of our lives on earth as biological creatures. Linkages between our electromagnetic and bio-chemical or neuro-chemical systems are documented in this literature together with macro-behavioural symptoms such as sleepiness, irritability and hyperactivity. Very little room is left for doubt that we are individually coherent biological open systems. Secondly, much of the work discussed here has shown conclusively that the human body itself is a saline pool that acts as a conductor of electricity in an electro-magnetic universe. Our fundamental biological frequencies as measured by EEG include those of the ambience itself, a phenomenon we share with the other creatures of the earth. We are in fact extraordinarily attuned and sensitive to the most basic properties of our world.

The history of these biological frequencies and their rise to importance, and the pathetic story of their attempted cover-ups by sections of the scientific establishment have been reviewed by the Saturday Review (Schiefelbein, 1979). Microwaves for example have been implicated in "central nervous system disorders, genetic damage, reductions in the brain's electrical activity, loss of memory, and malformations of the foetuses of exposed animals." 30% of cases of cataract caused by nonionizing radiation were in air traffic controllers and commercial airline pilots. Headache, fatigue and reduction in sexual capabilities are commonly reported as microwave effects. (Schiefelbein, 1979, p 18) This article mentions Hans Selye's findings of biophysical stress on hormonal responses (p 20) and Becker & Marino's evidence that an ELF field near the head of a human had induced anaesthesia together with a range of effects in other species. (p 19, my emphasis)

Fortunately, as much of the data has been either ridiculed and/or censored by U.S.A. agencies, some of the original workers in this field were brought together at the University of Ottawa in an 'International Forum on Low-Level Electromagnetic Radiation and the Question of Video Display Terminals'. (June 4th, 1982)* Dr. Robert Becker began his talk -- "In the late 1950s we were successful in establishing the fact that growth processes are stimulated, regulated and directed by electrical control systems that reside within the living organism. Now as part of the study of those control systems I utilized the interaction between those systems and external electro-magnetic fields." (p 18) the assumption at that time concerning the effects of electro-magnetic

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* I am indebted to Bill Kuhns, Professor, Department of Communications, University of Ottawa, for this orignial transcript of the video programme.

radiation was governed by Newtonian physics, namely that there will be no biological effects unless the size, the amplitude is sufficient to produce shock or heat. But the panel of experts reviewing studies prior to the introduction of Project Sanguine, a very large array antenna designed to operate at ELF and communicate with submerged submarines, found disturbing biological effects for an intensity a million times smaller than that found at the edge of the right-away of the 765 KV powerlines. They notified the U.S. Navy that major segments of the population of all civilized countries may be currently at risk and that the project should not proceed. Their report was buried and until leaked, the navy continued to lie to the Senator concerned, to the effect that there was no evidence of any biological effects. (p 19)

Subsequent to his discoveries that biological effects were significant in animals, epidemiological studies linked "psychological disturbances and particularly suicides to exposure to electro-magnetic fields of power frequency ratiation at 60 Hz. (p 19) An epidemiological study conducted in Denver, Colorado has shown a correlation between death from cancer in children and proximity of residence to power lines. Homes close to transformers and sub-stations were particularly over-represented among the cancer cases. High current flows and the induced magnetic fields rather than voltage, appeared to be the relevant agent." The most significant difference between cases and controls was found for subjects who had only one address from birth to death." (Wertheimer & Leeper, 1979, p 278) Also, the incidence of cancer appeared to be directly dose-related and not a function of time. (p 279)

Wertheimer and Leeper are careful to point out that the risk of cancer for children living close to 'high current configurations' is "rarely

increased by a factor of more than two or three" (p 283) and that the significance of the findings inheres in the prevalence of these high current configurations in modern life. They are also reluctant to posit a direct relation between ELF and incidence but suggest a possible indirect link with physiological processes. Against an electromagnetic background different from that provided during evolution, all mechanisms involving recognition of surface electrical potentials may be altered. (p 283)

Comprehensive and cautious as this study was, it has been controversial with debates in Science (Wertheimer & Leeper, 1983). It appears tempting to look for methodological reasons for dismissing such disturbing findings. But since that study, others conducted around the world have confirmed the danger of power lines. Children living within the vicinity have for example 2-5 times the normal leukemia rate. (Personal communication from Kuhns, 19.11.83).

For his trouble taken in regard to public health, Becker lost all his research grants and the support of his own agency. He continued at The Forum in response to questions: "Pulsed electro-magnetic fields produce an increase in the mitotic rate, the cell multiplication rate, of any tissue or any structure within the body that is engaged in cell reproduction" (p 23) Dr. Glen Rein reiterated that "electro-magnetic fields regulate certain physiological processes . . . we can manipulate the energy system within the body by electro-magnetic energy from without the body" (p 26) and at levels many time(100x) less than those in the body. A unique property of radiation is its specificity at certain dosages; the 'window' phenomenon. (p 26) Sensitivity ranges also vary with circadian and other biological rhythms.

"VDT operators are living in a sea of 60 cycle radiation in the city and they are exposed to a much higher level of it while operating their machines. The stress . . . is a very real factor in those people." (Becker, 1982, p 23)

William Bise raised the issue of electrostatic fields:

> "VDTs with this high voltage cathode ray tube accelerating potential, could have at the front of that tube itself more than the 50,000 volts, if that's the maximum voltage used in a particularly large terminal. If this electrostatic field is pulsed, moved by a magnetic field, this could act as a reinforcing modality so then one would have not one of the electrostatic or the pulsed field but a pulsed electrostatic field.
>
> The source of that pulsed electrostatic field seems to be the operation of the computer unit of the VDT. Everytime an operation sequence is completed, at least this is what I've seen from group measurements that I've performed, the sequence produces ELF-like pulses. Some of the frequencies ranged between 3 to 5 Hertz -- those are biologically active, there were also some 30 Hertz oscillations as well as some 8 and 12 Hertz oscillations. I also noted some interesting spike-like waves up to 40 Hertz or so which may very well be the most significant." (p 25)

From the literature surveyed in Chapter 13 above,we would have to agree that these 'spike-like waves' would certainly be of significance.

During the course of his research Dr Robert Beck confirmed the dominance of the 7.8 Hz frequency, one of the harmonics of the Schumann resonances predicted in 1952. For mass demonstrations of a small ELF pacer this frequency is safe. "Life evolved in this frequency . . . (which) is not psycho-active" (Bise, 1982, p 33). Using his own equipment (a pocket-size magnetometer) assembled from components bought at the local electronic shop, Beck engaged in a little "illegal" research which proved that human behaviour is alterable by low level transmissions within the psychoactive (EEG) frequency range. Depending on the frequency

transmitted, he could either quiet a room full of noisy excited poeple, or raise its tension and decibel level. There is no reason to query the evidence of this man as the verity of his work has been confirmed by Zaret who was asked by the CIA to investigate the irradiation of the U.S. embassy in Moscow. The CIA had established that the signal had not been intended for listening in on embassy conversations or for jamming the surveillance equipment. Zaret concluded "Whatever other reasons the Russians may have had, they believed the beam would modify the behaviour of personnel." (Sheifelbein, 1979, p 17)

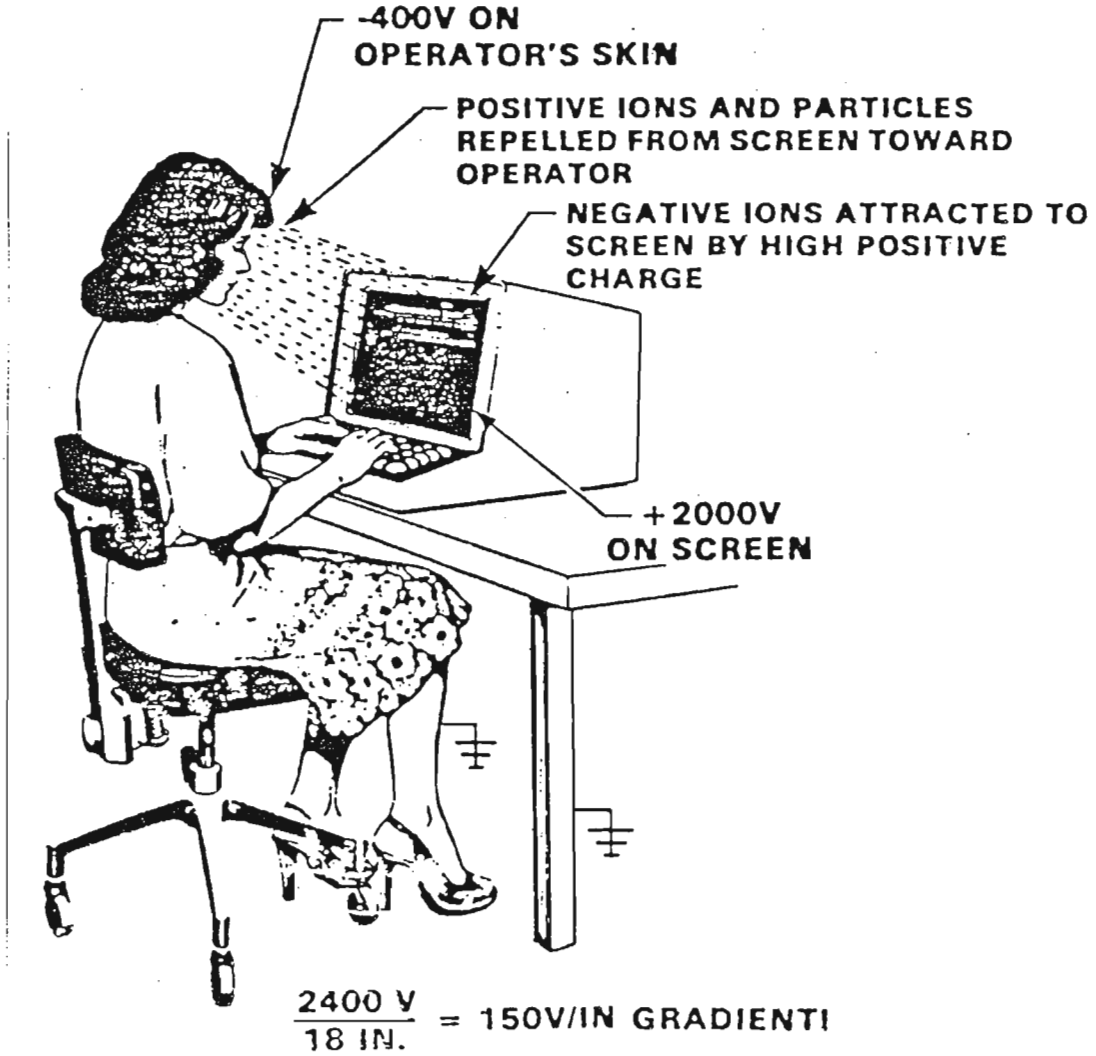
Eldon Byrd has monitored his TV set and shown that there are non-linear ELF signals emanating from it. Non-linear signals seem to interact with living systems and living processes much more easily than linear signals do. Inside the TV, there are processes that convert some electrical signals into non-linear types (p 49) A non-linear signal is one which contains an exponential component and results in a non-proportional output. "Living systems are virtually totally non-linear" (Byrd, p 49) Linear models simply will not fit this data.

While it is very easy to shield oneself from an electrostatic field, ELF penetrates anything; "there is no place to hide" (Beck, p 29). And as we have seen the frequencies are in the range of human brainwaves. Bise noted that washing machines and dryers put out more ELF energy than VDUs but our contact with them is brief and infrequent.

The electrostatic gradient which serves as a pump for negative and positive ions may also be involved in VDU operator symptomatology. Figure 14.2 taken from the proceedings of this conference (p 58A) illustrates the phenomenon. Women are in general more sensitive to ion

depletion and show changes in serotonin and various thyroid conditions (Beal, 1982, p 57-58). An excess of positive ions tends to enhance eye irritation and induce headaches, fatigue and nausea. Placing the operator between the screen and a negative ion generator will remedy this source of discomfort.

Figure 14.2 VDT Voltage Gradient Versus Air Ion Behavior



The largest volume of occupational health complaints reported to NIOSH during 1980-1 involved symptomatic VDT operator distresses including headache, skin rash, eye irritation, backache, fatigue and nausea.

These same symptoms are associated with ion imbalance and/or depletion in many other environments where iconic parameters have been accurately measured.

This suggests that the effects of the gradient illustrated above are to (1) raise the PNIR by scavenging negative ions, (2) repel positively charged particles towards the operator's face, and (3) repel small positive ions out of the ambient airspace, thus creating a net ion depletion.

In reply to a question James Beal (p 47-8) documented evidence about sensitivities to ultra sound between 15-30 Kilo Hz coming from TV sets to which women are more sensitive. About "one-third of the population is extremely sensitive to electro-magnetic changes -- primarily women, children and older people" (p 48). Older people become tired and drowsy, children become hyperactive. The two thirds who are not extremely sensitive show their reaction by an increased serotonin concentration in the urine (p 48). The signal is not always heard but often <u>felt</u> as a pressure of some sort, causing headache, nausea and strange flickering sensations of the visual centre. These ultra sound levels have been found to run to 40 to 50 decibels (Byrd, p 43)

Bise & Beck demonstrated at the conference their inexpensive mangetometer. Bise (p 34) said "There's no way we can shut down all the VDTs or the TV sets, and quit using technology. What we've decided to do is that if we don't like the <u>external field</u>, we turn on that we like. So, we put this device in our pocket. It is like adding an external blanket field around our bodies . . . people could put this device in front of VDTs and still use the equipment without having to put up with the frequencies which are indeed psycho-active, the ones that affect brainwaves."

It is to be hoped that in the absence of an alternative to CRT technology such a solution will be implemented. This should drastically reduce the incidence of disorders induced by this maladaptive technology. It should also be noted here that gas plasma screens are in existence although not generally commercially available. But as DeMatteo et al note (1981, p 33) while these do not flicker, they do contain ionized gases and it is time to ensure that we don't substitute a new hazard for the old.

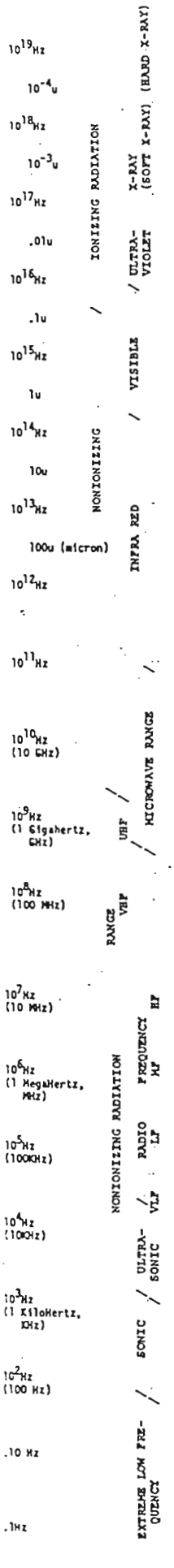
In Summary

If a check on the maladaptive nature of domestic television was required, it would appear that the VDU and attendant research into ELF has more than filled the bill in this regard. The CRT has maladaptive effects linked with virtually every band of the electromagnetic spectrum from ELF through visible frequencies to ionized radiation. This latter becomes a problem only when the heavy shielding fails, but quality control procedures have been shown to be inadequate. Of special note in this brief review has been the finding that a common core of response is associated with every level of the EM spectrum. Visual dysfunctions, headaches, fatigue, loss of motivation and irritability are regularly associated with imbalances in the normal environment caused by one or a combination of EM frequencies. Synergistic effects are to be expected. Apparently this level of reaction is the body's natural first line of defence to a maladaptive econiche. For those who are extremely sensitive to radiation in either the visible or invisible spectra, the response will be an epileptiform one. For those who are less sensitive, the response will be that of the common core. However, over time, as we have seen, some of those mildly sensitive people will develop a more severe response due to system overload and kindling effects. CRT technology

appears to have little to recommend it as the central feature of the workplace or the home entertainment system.

EM & VDTs

AN OVERVIEW



vdt source	findings	standards
Soft X-Ray Produced by the high voltage in a cathode ray tube, and dissipating in intensity by the square of the distance from the source.	BRH, February 1981: 34 VDTs tested for x-radiation; none emitted x-radiation above 0.5 milliremas per hour	X-Ray Emission Standard occupational, for Canada and the U.S.: 2.5 millirem (mR) per hour Ultraviolet Emission Standard, Canada and U.S.: 1 milliwatt/cm^2
Ultra-violet, Visible, Infrared produced by the photonic stimulation of electrons hitting the phosphor screen, and other effects.	BRH, February, 1981: Emissions considerably lower than standards for UV and visible light	Visible and Infrared Emission Standard, Canada and the U.S.: 10 milliwatts/centimetre squared
		Microwave Emission Standard, Canada: 1 milliwatt/cm^2 U.S.: 10 milliwatts/cm^2
125 KHz - 150 MHz With slight exceptions (reaching high as microwave range) most tests indicate VDT RF radiation in the frequencies of AM, FM, VHF.	Weiss & Petersen, 1980: RMS electric field strength at frequencies below 30 MHz was .01 volts per meter at maximum; the Czech standard (world's most stringent) is 10 V/m.	Radiofrequency (RF) standards (above 10 MHz): Canada : 1 mw/cm^2 U.S.: 10 mw/cm^2 No federal regulations (in Canada or the U.S.) which apply to radio frequencies below 10 MHz.
15 KHz - 125 KHz low frequency radiowave radiation created by the deflection system and pulsed on and off approx. 15,000 to 20,000 times per second.	BRH, February, 1981: 95% of RF radiation between 15KHz & 125KHz	
Extreme Low Frequency (ELF) frequencies lower than 30 cycles per second (or 30 H) are created by the high voltage flow and the deflection system.	In the studies cited, only the BRH detected the emissions at extreme low frequencies	No federal standards exist in Canada or the U.S. for emissions at extreme low frequencies

Sources

M.L. Wolbarsht, et al, "Electromagnetic Emission from Visual Display Units: A Non-Hazard," 1980;

M.M. Weiss and R.C. Petersen, "Electromagnetic Radiation Emitted from Video Computer Terminals," 1980;

Bureau of Radiological Health, with The World Health Organization, "An Evaluation of Radiation Emission from Video Display Terminals," February, 1980

Conclusions

"In no part of the spectrum are the emission levels anywhere close to that of a maximum threshold limit value or acceptable permissable exposure ... they are always below these acceptable levels by a factor of 10 to 100 or even more." (Wolbarsht, et al).

"There is no evidence to indicate that the emissions associated with the terminals investigated, will have any adverse effects on the health of personnel using these devices." (Weiss, Petersen)

"In general, emission levels from the terminals tested, both under normal operating and worst-case conditions, fell within the standards and guidelines currently in effect for each type of radiation." (BRH)

Conclusions

The data reviewed in Parts II and III leave little doubt that the overall thesis of maladaptivity is supported. There is a coherence and internal consistency between the two levels of analysis which is superordinate to the support for any specific sub-hypothesis, and which in itself raises hopes that the question of adaptation in general may be validly appraised by a systemic methodology. However, as these items were expected to form a framework for the main thesis and a total failure of one or more would cast doubt on it, we review them separately to ascertain their status and contribution to the whole.

At the medium-term level of directive correlation we proposed:

1. Television is a maladaptive econiche as it affords only familiarity or knowing 'of', not an immediate accurate perception of the real environment which is at least at the level of knowing 'about'.

2. There is more forgetting, not knowing, than remembering of TV content. Where there is remembering, knowing 'of', it will carry a high probability of being inaccurate, lacking in invariance.

3. The effects of television in both the education and marketing systems can be effectively measured only by tests of recognition. Tests of recall will reveal an absence of knowing 'about' and understanding.

Five cases studies and the chapters 6 to 10 present significant confirmation of these hypotheses. Television affords primarily a sense of familiarity or knowing 'of'. There is more forgetting than remembering of the content and in our discussion of product marketing we have noted the miscomprehension or inaccuracy rate, even when measured by recognition. Extensive analysis of the use of tests of recognition and recall has shown that the knowing derived from televiewing is rarely amenable to recall. Children fail to learn concepts and do not remember much of television's iconic content. In cases where recognition has elicited knowing 'of', it has also been demonstrated that there is little

if any, generalization of the knowing. It is a particularly discrete and discontinuous form. But the fact that recognition can more reliably than recall, provide evidence of 'learning', has been exploited as a loophole through which the ETV producers and promoters (including their academic research arm) have continued the deception and escaped the necessity of facing up to the real consequences of their promotion.

When knowing 'about' and understanding have been demonstrated, we have also shown that this knowing has arisen from co-viewing and discussion. Other people are the real source of this learning. Conversation is by far the more powerful medium for genuine learning. But television inhibits conversation and other natural, non-verbal forms of associating. Adult learning from so-called informative programming is also minimal and a-conceptual; again the data point to familiarity rather than accurate knowings. Television in the service of well-informed democracies has failed. We do however, leave a question mark hanging over the political 'issue versus image' debate.

These hypotheses 1-3 were the critical tests for the thesis at the ontogenetic level. Even without the others, these results would have been sufficient to conclude that television does not expand the total set of directive correlations or in other words, support purposeful learning and the generation of consciousness. It is not an educational medium in any but the most minimal sense. The large scale experiments with television as teacher confirm this view. Over time, a pattern of rapidly diminishing returns convinced the populations that the experience was in fact, positively disadvantaging and the systems were dismantled. Evidence from other studies has shown their judgements to be correct in this.

Indeed, various pieces of data lead to the general conclusion that the seduction of this minimal function of knowing 'of', together with the insistence of many psychologists and educationalists that the medium is educational, has lulled us and our children into a decidedly blissful state of ignorance and disadvantage. Our wholesale submission to this message from the experts and the authoritative medium itself, must bear some responsibility for our flight into illiteracy and unmotivated behaviour. Noticeable declines in imagination and creativity have been directly tied to time spent watching TV and as these distincitive human competencies are also the hallmarks of an expansive set of directive correlations, this data provides yet another line of support for the overall thesis.

Chapter ten specifically addressed hypothesis 4:

4. Maximum contrast is achieved when comparing the knowings obtained from reading print and televiewing. Recall is appropriate for reading and will show knowing 'about' and understanding.

Here we found not only evidence confirming the hypothesis but that on a broad scale; coherent constellations of differences, to the point where there has been speculation about the emergence of a cultural split between 'the readers' and 'the viewers'. These differences encompass intellectual abilities, lifestyle and values. Viewers may still read, but the choice of material and their approach to it is qualitatively distinct. Reading for the heavy viewer appears little more than a minor extension of the television-generated world itself.

The chapter on product marketing had already dealt with hypothesis 5, namely:

5. Television does not fulfil the four conditions for effective, influential communication.

It does not fulfil them in the sense in which Asch meant them, i.e. as productive of learning and knowing 'about'. Thus is resolved the paradox inherent in the inclusion of this hypothesis 5 in a chapter dealing with the success of television as a persuasive marketing tool. The success of TV in marketing is a direct consequence of the same set of factors which ensured its failure as education. Television marketing relies on the fact that there will be a lack of recall. Into these tabula rasas novelty can be continuously introduced. Maximum potential for recognition with minimal repetition however, is generated through positive affect and avoidance of information. Both visual and linguistic tricks are employed to enhance the desired effect.

6. Watching television produces an almost constant, and therefo maladaptive state of muted positive affect. Its signature is the slack-jawed, low energy smile.

The predominant affectual response to the medium is dealt with at both levels of analysis. Dissecting the production techniques for the news and advertisements, and their trends over time, is sufficient to confirm that the industry knows precisely that they are working with an auditory-tactile and warm, affective medium. Chapters 11, 12 and 13 cover the phenomenon with direct observations of viewers; the characteristic relaxation with an increasing lack of tension in the system, the self-induction of television epilepsy with rewards gained, and the relation between increased theta activity while viewing and the pleasurable, drowsy, hypnagogic state.

At another level, the point has been taken further in discussion of the disadvantaging effects of a heavy viewing lifestyle and the relation of personality to vulnerability. Our hypothesis:

7. Individual differences in sensitivity to the medium as measured by an open systems definition of personality, account for the range of responsiveness, liking and disliking, and also the range of neurophysiological states.

has received some confirmation but more work is needed here. Sensitivity to environmental affordances does appear to account for both reactions and responses to CRT technology, and as television replaces contact with reality (hypothesis 8) these sensitive people appear most at risk from the dissociative consequences of heavy viewing. These are the same people who seem to gain great pleasure from being immersed in the effects of the technology and who become involved in its content. Others who prefer their own inner realities, find its seductive effects annoying and avoid it.

We will take hypotheses 8-10 as a group.

8. By becoming a substutute for reality, television both reduces the opportunity for, and inhibits the learning and development of basic skills, particularly those of associating; spoken language, conversing and expanding the panorama of significant group ties. Television is therefore dissociative

9. Heavy viewers will show diminished competence in, and motivation towards associating, with accompanying signs of stress and distress.

10. Heavy viewing cultures will be characterized by dissociation with overtones of other maladaptions and distorted perceptions of reality.

From the case studies emerged a picture of dissociation, disadvantage and cultural withering or homogenization. The chapters on children's and adult's learning note both aspects of the dissociative effect;

substitution of viewing for conversing, playing, transacting in the service of group life, and the direct effect of reduced cortical activi as diminished intellectual activity and interest. Destruction of unique, stable cultures was also addressed in chapter six and the obvious answer to the question of exporting television and its automatic cortege of western products to 'lesser developed countries' is that this is not development in any adaptive sense. Traditionally associating cultures fall rapidly into dissociating.

Hypotheses 9 and 10 were highlighted in the overview of television and the disadvantage cycle, after the analysis of adult learning made it clear that heavy viewers perceive a distorted reality and in fact, have very little insight into the processes afoot in the world. In the political sphere at least, there is evidence of the dissociative vacuum being filled by active maladaptive strategies, not the least of which pacification by television. The passive maladaptive spiral shows its consequences however, at the personal as well as cultural level, and there is evidence of psychological distress amongst heavy viewers. Viewing is a warm, positive experience of a simple, to the point of stereotypical, reality, and conveys a feeling of involvement: venturing outside this econiche can be fraught with emptiness, complexity and uncertainty. The crisis of television truly only starts when you turn it off. (except for television epileptics)

At the medium -term level of directive correlation there is no reason to reject the overall hypothesis that television inhibits learning and the potential for consciousness. Our adaptation, and continued ability adapt, depends largely on environmental vigilance where the environment is the extended field of cultural and physical realities known

immediately and directly by the perceptual system; that is, unmediated and not reliant on only one or two of the subsystems.

Because of the comprehensive and systemic nature of our analysis there are a variety of corrollaries and asides which have emerged at the ontogenetic level. They are noted in the conclusions to the various chapters and only the most significant will bear replication here. Firstly, we have explored the dynamics of successful recognition as they are exploited for marketing. The probability of recognizing, and therefore buying, increases as the item to be recognised is more discrete and tangible, and the message is positively directed. Branded products advertized with a unique selling proposition (USP) with a message to 'feel good' are therefore the natural forté of the medium. As an item is less concrete and more conceptual, or the message is negative such as in avoid buying or doing, so will the advertising or other televised communication be less effective. Using these dynamics we have begun to see more clearly that the hope of reformers for pro-social television is mostly doomed to failure. Only those concepts which can be transformed into products and for which the message is positive, stand a chance of effective recognition and acceptance. As conceptual ETV failed, so will most pro-social TV. Other factors such as the appropriateness of the medium for relaxing entertainment means that a lot of high quality and pro-social content is not turned on, as it has become known to be boring, or 'hard work'. The reduction or slowing of cortical activity is sufficient to account for its failure so far and our pessimistic prognosis. Medium, not content, is dominant and the industry has learnt to shape the content to fit the demands of the medium.

Secondly, there is substantiation for our analysis of television in the context of causally textured environments. The genotypical features which have emerged at the level of medium include the following: the tie to recognition without benefit of consciousness or purpose is probably as close as humans can come to genuine conditioning, indeed, television may present one of the few pure cases. TV-person relations are bureaucratically structured as the signal effectively imposes its own hierarchical domination and it does instruct, although the result is merely that of knowing 'of'. In terms of content, we see a constant changing aray of particulate icons which alternatively present a world which is random and dangerous, magical solutions to problems and escape into passive, archetypal and pseudo-involving entertainment. All aspects are introduced by warm, friendly inviting hosts. The results of this oligopolistically nurtured fantasy is a materalistic, consuming, dissociated culture losing a sense of organization (laissez-faire) and whose orientation, if such it can be called, is inwards. Television time has become the eternal 'here and now' and this for a species which is known as 'the time-binder'!

Television is therefore most appropriate for a random, placid social field, has some appropriate function within a disturbed, reactive field, can play only a minimal role as tranquillizer in the adaptive evolution of the current turbulent field, and has virtually no adaptive function within a mature clustered, placid field. At this level of analysis the system principle appears as a self-generative spiral of immediate, short-term gratification leading to a replacement of reality by fantasy, with narrowing and foreshortening of the total set of directional correlations. Television is the technological uroboric snake.

At the short-term level of directive correlation we proposed hypotheses 11 and 12.

11. CRT technology is maladaptive in that it induces a set of neurophysiological system states, all of which by definition cannot satisfy the focal condition of adaptation.

12. The range of effects of VDU's will parallel those of television and confirm that it is the CRT which induces the maladaption.

Chapters 11-14 address these hypotheses and the sub-clauses of the overall hypothesis which were drawn from the Emery's 1975 research and further elaborated herein, namely;

- the 'information' communicated by the signal causes fixation and hatituation, a reaction rather than a response
- radiance, repetition and the resulting attensivity which suppresses environmental vigilance, produce reduced cortical activity or a diminished cortical firing rate
- at the ontogenetic level, this means a reduced alertness and capacity for purposeful learning, understanding and consciousness

In chapter 11 we concluded from a survey of direct testing of television's effects and related data that we could sustain the thesis in terms of both habituation and our inability to extract information from radiant light. Habituation has received further support from the investigation of television epilepsy and in particular, the 'kindling' model. All chapters have, from various perspectives, added support for the notion that the CRT as a radiant light source creates severe difficulties for the human perceptual system. There is definite evidence of cortical slowing as measured by the EEG. Relativities of fast to slow wave activity are shifted towards the slower end of the scale. Content has been show to play a role in determination of these ratios but its influence appears to be minor.

But there has still been no appropriate and clear cut test of the original hypothesis and until this is conducted, preferably with one of the new nuclear brain scanning technologies, we cannot definitely conclude that it has been confirmed. Despite accumulating circumstantial evidence at the perceptuomotor level and certainly confirmation at the level of learning, this remains as a gap in the picture.

Hypothesis 11 is supported however, despite this gap, as we have shown clear evidence of a range of system states, the epileptic one of which is of course, a maladaptive reaction in its own right. Maladaptivity is established at this level. A brief survey of the literature on VDU's has similarly confirmed that the problem is not confined to television but is a feature of CRT technology in general.

In attempting to clarify what appears to be the modal reaction to CRT's, increased theta activity (Chapter 13), the system state intermediate to normal function and epileptic, we have also noted the correspondence between relative increase of theta appearance and reduced environmental vigilance at this level, and the characteristic of knowing 'of' as an ecologically incomplete form of knowing at the ontogenetic level. This is supportive of the concept that there is a coherent, systemic response; in Krugman's terms, 'a characteristic mode of response' which we can now specify quite precisely as a breakdown in the directive correlation itself. Not only are the sub-hypotheses at each level mainly confirmed, there is also evidence identifying the two sets of results as a coordinated, or more accurately, a holistic response to the technology. We should perhaps also mention here that although further empiric testing is required, there is no evidence in the literature to support an anti-thesis.

Taken together, our hypotheses, the kindling model and the distinction between recognition and recall defined as ecological concepts, allow us to explain the observed behavioural deficits at the systemic level. We conclude therefore that CRT technology induces maladaptive behaviour and is a maladaptive technology.

This is the first level of evaluation. The second or broader aim of developing an open and ecologically realist systems approach to evaluating our artifacts must ultimately be judged by the reader. However, in this context we may review the second thread which has run through this work. This is of course, the failure of the Euclidian-Newtonian paradigm to predict or explain the effects of CRT's. Still in vogue with establishment social science, it has been shown to have failed, even terms of its own criteria for validity. Weddedness to it has led to grave disservices to our peoples and to the profession itself. Throughout the case studies and chapters of Part II, we noted the attempts to explain away, rather than explain, the hard empirical data concerning lack of learning from TV. Additionally, we noted the decline in conceptual clarity as fundamental distinctions between the processes of recognizing and recalling (remembering) were blurred and reports came to resemble well-sounding gibberish, worthy of Lewis Carroll.

This paradigm has also accelerated methodologically, but fared no better than it has conceptually, in both the social science and neurophysiological spheres. Fragmentation and attempted reconstruction by procedures such as factor analysis have succeeded only in hiding the big picture. Re-analyses by holistic methods have demonstrated not only how erroneous the conclusions may be from such reductionist research, but

also the latitude they permit for the intrusion of subjective rather than objective features. Similarly, at the level of EEG research we have documented the search for the pure cognition, and the sterility which has accompanied this most rigorous of experimental ventures into logical positivism. The belief in a continual process of decontaminating the EEG record of all behavioural 'artifacts' has produced a vacuum, but it has also by default cast doubt upon the traditional interpretation of the EEG and opened the way for novel and more systemic methods. These rely not on reductionism but metabolic patterning, itself a more contextualist approach.

Then we note the correspondence between these newer techniques and the analysis made herein of consciousness, learning, remembering and forgetting. The emphasis is on process and we have shown that the Newtonian concept of memory as a storage and retrieval unit is totally unnecessary. We are not machines with memories into which are pushed and out of which are dragged, lumps of information. We have also surveyed evidence which demonstrates unequivocally that the concept of 'the mind' as a set of cognitive compartments is not matched by neurophysiological activity. A new interpretation of the EEG has therefore been offered which better accounts for the data. The EEG can be seen as a set of scanners for different levels of the directive correlation.

If social science is to regain a useful stance, a paradigmatic shift is required. We have suggested that the embryo for this transformation is alive and well. Hand in hand, ecological realism and open systems thinking may emerge as a lively contender for the future. Should this prove an accurate reading of the entrails, we would hope to see a return

to the excitement of research opportunities offered by such insights as 'thing and medium' and 'the medium is the massage'.

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