Predicting Memory for Components of TV Commercials from EEG

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Subjects watched television while EEG was being recorded and later completed a series of recognition tests based on component parts of the commercials they had seen. Memory correlated significantly with changes in the electrical patterns that occurred during viewing. The probability of correct recognition was enhanced when alpha blocking continued for a longer period of time and when hemispheric laterality shifted to the right during the onset of a commercial component and then to the left during the following seconds.

A recent article by Rothschild et al. (1988) reported an inability to replicate earlier findings (Rothschild et al. 1986) relating EEG (electroencephalograph, brain wave) data to memory data with respect to the viewing of television commercials. The earlier data showed a significant relationship between the aggregate EEG across an entire commercial and overall memory for that commercial. These results had been found for immediate and delayed recognition and immediate recall of the commercial.

The discussion of the lack of replicability in the later article showed that findings in the advertising literature with respect to this linkage had been unreliable for other researchers as well. For example, Weinstein, Appel, and Weinstein found the linkage in one study (Appel, Weinstein, and Weinstein 1979) but not in a later one (Weinstein, Appel, and Weinstein 1980). Other researchers also have reported weak or no relations between these aggregate variables (Rockey, Green, and Perold 1980; Rust, Price, and Kumar 1985).

One possible reason for the inconsistency in the observed relationship between EEG and memory may be that most research has used 30-second units for analysis. Rothschild et al. (1988) proposed that EEG data for short periods of a commercial may be more likely to correlate with memory for individual scenes or claims; this article will take this approach in examining the relationship between EEG and memory. Rather than pursue an aggregation tactic, we will present a method for examining EEG data for short periods of a commercial and linking these data to memory tests for the components of the commercial occurring during these periods.

LITERATURE REVIEW

A review of a few aspects of the basic psychophysics literature describes the links between the patterns of electrical activity observed during the receipt of a stimulus and the later response of retrieval from memory.

Voluntary Versus Involuntary Alpha Blocking

Mulholland (1973) has written that the initial drop in alpha frequency brain wave activity is an involuntary reflexive response to a change in the environment that needs to be evaluated. After the drop in alpha power known as blocking takes place, the degree of the blocking and its time length are a voluntary activity. The degree and time length may vary depending upon how much information in the stimulus is processed, i.e., attended, assessed, and/or memory encoded (John and Schwartz 1978; Mulholland 1973).

While the initial drop in alpha is not discriminative across stimuli, the following alpha blocking should be discriminative. Just as more information processing of a stimulus leads to higher memory of the stimulus, so should more voluntary alpha blocking also lead to higher memory of the stimulus.

Hemispheric Lateralization at the Occiput

There are several currently popular explanations for the fact that electrical activity may be blocked

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more strongly at different times in either the left or right hemisphere. (Since the data presented in this article were gathered from the occipital lobe, all further discussions will be limited to this location.)

Four potentially independent sets of lateralizing variables are:

1. Vigilance versus learning mode of receipt of stimuli (Barchas and Perlaki 1986; Dimond and Beaumont 1973);
2. Verbal versus nonverbal stimuli (Bryden 1982; Davidson 1988; Luria 1973);
3. Level of clarity and complexity of stimuli (Bryden 1982; Sergent 1983);

This study is concerned with the first issue only; variance due to the others was not controlled but considered a random contribution to the error term in later analysis.

**Vigilance Versus Learning Modes in the Receipt of Stimuli.** It has been suggested that the right hemisphere is more vigilant and does initial processing, while the left hemisphere takes over when stimuli are felt to be important (Dimond and Beaumont 1973; reviewed by Krugman 1980). Dominance shifts as the stimulus increases in importance in the subject’s mind. In the domain of hemispheric dominance or laterality, left hemisphere processing is felt to show effortful, intentional attention, while right hemisphere processing is less analytic (Dimond and Beaumont 1974).

Barchas and Perlaki (1986, p. 348) cite Dixon (1981) as showing that the right hemisphere is “implicated in . . . preconscious processing.” This model of processing is similar to that proposed by Bryden (1982), which suggested that the two hemispheres differed in terms of analytic versus holistic modes of processing.

Rhodes (1985) has presented a similar, hierarchical stages model of lateralized processes in face recognition. This model suggests that early visuospatial processing is dominant in the right hemisphere, while later cognitive processes of comparison of facial representations may yield left hemisphere dominance. The early process is more spatial and holistic, and the latter is more semantic and analytic.

**Accommodating the Four Views of Laterality.** Each of the four explanations of why hemispheric laterality (dominance) exists is correct within the confines of each one’s experimental paradigm. In a less controlled setting, each will contribute to laterality, which is why laterality is so difficult to observe in a natural environment. Each view will predict laterality when a simple verbal or nonverbal stimulus is presented tachistoscopically in either the right or left visual hemifield for a period of 10 to 400 milliseconds; however, the reality of a complex and changing ongoing stimulus is nothing like this simple, static one.

It is neither necessary nor useful to reconcile these views because they all exist and interact in a natural setting. What should be noted, though, is that no literature considers laterality within the context of anything remotely resembling a television commercial in either length or complexity.

**EEG, Arousal, Attention, Information Processing, and Memory**

A number of studies have considered at least some part of this set of relationships. In almost all cases, the method involved a brief stimulus presentation; some of these stimuli were nonsense syllables, and others were words that could be arousing or emotion-laden.

Some works have considered physiologic responses during the retrieval process (Brown 1937; Kintsch 1965; Lacey 1967; Thompson and Obrist 1964), and others have considered physiologic change during the exposure period. Kleinsmith and Kaplan (1963) found better memory for words that elicited arousal (as measured via galvanic skin response) during exposure. Maltzman, Kantor, and Langdon (1966) and Corteene (1969) found similar results. In a review of this area, Craik and Blankstein (1975, pp. 402–403), concluded that “higher arousal at presentation leads to better long-term retention” and that “it is well known that learning is positively related to the amount of attention or processing the item received.”

As a specific operationalization of arousal, several studies have considered alpha blocking during the time of exposure to the stimulus. Thompson and Thompson (1965) found increased alpha blocking and increased beta activity during learning of a list of nonsense syllables. Warren, Peltz, and Haueter (1976) compared the level of recall of words to the amount of alpha blocking at the time that the stimulus words were first presented. They found that a higher level of recall was associated with a greater amount of bilateral alpha blocking but that asymmetry in alpha was not related to recall. In their study, bilateral blocking was felt to show arousal; asymmetry was created by coding instructions (imagine versus describe) and was, therefore, not allowed to vary freely.

The relationship between attentiveness and task performance has also been shown by Gevins and his colleagues (Gevins et al. 1981, 1987). In this work, subjects were asked to perform a complex reaction time response task, which varied according to symbols flashed on a screen, while EEG patterns were being recorded. The researchers concluded that performance level was a function of attentiveness just prior
to, and at the moment of, exposure to the directional signals. EEG patterns varied across a large number of locations and were correlated with performance and quality. ERP (Evoked Response Potential), another research paradigm for examining the electrical patterns of the brain, contains many studies that show the relation between electrical changes and memory. ERP work is not transferable to the study of a complex, continuous stimulus, such as a television commercial, because of an incompatible method. The simple stimuli used are generally presented for less than 250 milliseconds in a controlled visual hemifield and are repeated up to several hundred times; the average of the electrical patterns over all trials is then examined. Although the method is clearly unsuitable, the results of several studies show a clear relation between differences in electrical patterns and differences in memory. Memory has been shown to relate to ERP during initial exposure to the stimulus (Fabiani, Karis, and Donchin 1986; Paller, Kutas, and Mayes 1987; Sanquist et al. 1980) and during the memory test (Johnson, Pfefferbaum, and Kopell 1985; Neville et al. 1986).

Although none of these studies deals with stimuli as complex as those of a television commercial, the basic results consistently show that EEG as a physiologic operationalization of arousal, attention, or information processing is related to goodness of memory or performance. Prior advertising work in this area has been reviewed by others and will not be reviewed here.

HYPOTHESES

As discussed previously, given a stimulus, the initial drop in alpha is involuntary and the following changes in alpha are voluntary. In addition, a person is more likely to be vigilant toward the stimulus at the onset, while learning is more likely to occur in later periods. Based upon this work, two hypotheses are addressed:

H1: Occipital alpha blocking does not covary with memory of the stimulus during the initial period of exposure, but does covary with memory during later periods.

H2: Occipital hemispheric laterality covaries with memory of the stimulus such that there will be right dominance during the initial period of exposure and left dominance during the following periods.

METHOD

The following abbreviated method presents a summary of general procedures outlined in Rothschild et al. (1988) and a detailed presentation of additional methods unique to the present data set. For a more complete statement, the reader is referred to the earlier publication.

The right- and left-hemisphere occipital alpha EEGs of 21 right-handed women were recorded during the viewing of television videotape. Subjects viewed an acclimation/distractor videotape for about 10 minutes, completed a distractor questionnaire, and then watched a 27.5-minute stimulus videotape. The stimulus tape consisted of nine commercials (4.5 minutes in total viewing time), two minutes of TV black, and 21 minutes of programming. Three seven-minute program segments were each followed by pods of three commercials. The test commercials were selected from a group of 200 previously tested, 30-second color productions. Each advertised product was intuitively judged to be low involvement, and none of the brands was marketed in the test area.

Three videotapes were constructed to balance the order of programming, the order of commercials within the pods, and the order between the commercial pods. Subjects were assigned randomly to one of the three tapes. EEG data were collected during the viewing of the stimulus videotape, although electrodes were in place for both the distractor and stimulus tapes.

After watching television, subjects completed a distractor task of program evaluations. The next task was designed to study the link between EEG and memory found in Rothschild et al. (1986). In this test, respondents were given recall and recognition tests after a half-hour delay. The recall test asked subjects to list the product category, brand name, and claims as many of the nine commercials as possible. After completing the recall questionnaire, subjects received a four-distractor recognition questionnaire that listed product, brand, and claim choices on consecutive pages for each of the nine commercials.

As stated previously, the study of this topic by Rothschild et al. (1986) found a relationship between recall and recognition of the overall message and overall EEG, but this finding was not replicated in Rothschild et al. (1988). A more appropriate memory test was felt to be one focused on memory for components of the message. In such a test, subjects were shown a series of slides and script lines and asked if they were familiar with each stimulus. One hundred twenty slides and 98 script lines were shown in a yes/no recognition format; 55 of the slides and 42 of the script lines came from scenes in the commercials just viewed, while the remainder came from materials not seen during the experiment. Subjects were shown each slide for two seconds, then given 10 seconds to respond. Script lines were in the questionnaire booklet and had no time constraint. In addition, subjects showed the confidence they had in their decisions on a 10-point scale, which was based on correctness (yes/no) as well as confidence (a five-point scale) and...
PREDICTING MEMORY FROM EEG

which was derived in the manner of the Stapel scale (Churchill 1987). This procedure formed the basis of the memory test reported subsequently in this article.

The data were analyzed with respect to the half-second during which the slide or script line first appeared; i.e., memory was considered with the EEG patterns beginning at the onset of the stimulus as well as with the EEG prior to and following the onset. In its operationalization, onset consisted of the sum of the first two half-seconds of the scene or script. The next three half-seconds comprised the post-onset period, and the pre-onset period was the three half-seconds preceding onset.

Analysis was based on EEG power and dominance. **Power** reflects the voltage of electrical activity at one or more locations on the scalp as a measure of regional brain activity. Alpha activity (8–13 cycles per second) is the typical electrical frequency of choice by researchers working with normal subjects. When the brain (or some specified location within it) is at rest, there is synchronous activity at the cortex that is observable as a high level of electrical activity (typically an order of magnitude of about 50 microvolts) in the alpha frequency range. Any activity in which the brain engages will disrupt this synchronous behavior and lead to a lower power level of alpha; it is this alpha blocking that is observed through the power measure. **Dominance** reflects the relationship between the power at the left and right hemispheres of any homologous locations of the cortex. Because dominance is calculated as (Right–Left) and because lower values at any location indicate stronger cognitive activity, a negative dominance value indicates a larger left power value and, therefore, right dominance. Dominance is the measure used to observe hemispheric laterality.

The power and dominance results are based on EEG medians computed across subjects for each half-second after normalization (Z transformation) within each subject.

**RESULTS**

The hypotheses were tested to investigate whether there was a relationship between (1) patterns in EEG at the time that commercial components were viewed and (2) changes in later memory as seen through recognition tests. Observations were made for several half-seconds prior to the onset of the commercial stimulus component of interest, at the onset, and for several half-seconds after this onset. These observations were used to calculate both power and dominance measures of EEG. For example, in the correlation between (1) the change in power from pre-onset to onset and (2) recognition memory, the means for each of the pre-onset and onset periods were calculated, and the difference or change score between the two periods was calculated. This score was then corre-
based. In the Figure, each point represents a moving average of two consecutive half-seconds to aid the reader. In addition, only the most recognized 40 percent and least recognized 40 percent of the stimuli are used to show the separations occurring between the high and low learning components; this provides the data for the t-tests based on the differences between the most and least recognized stimuli.

Power

At Onset. There was a slight but insignificant drop in power at the onset period. The change was similar in response to both high and low recognition stimuli and, therefore, did not correlate with memory (r = 0.04; n.s.; n = 95).

Following Onset. There was a significant negative correlation between the power change across the onset/post-onset periods and recognition (r = -0.25; p < 0.01; n = 97). The Figure shows that the power data points for high and low recognition diverged from one another with the passage of time. The values of the two groups differed at t = 3 (p < 0.05) and marginally at t = 4 (p < 0.10). The components that elicited high recognition showed a continued suppression of alpha, while those that did not elicit strong memory showed an attenuation of alpha to the higher resting level of power.

Dominance

At Onset. There was a marginally significant negative correlation between the dominance change across the pre-onset/onset periods and recognition (r = -0.15; p < 0.1; n = 97). This indicated a shift to right hemisphere dominance during the period of the onset of the component for those stimuli that would elicit high recognition. The Figure shows the shift to right dominance during the onset period. The high and low memory groups differed at t = 1 (p < 0.05).

Following Onset. Following the shift to the right hemisphere that occurred during onset, a shift in the reverse direction occurred in the post-onset period. There was a positive correlation between the onset/post-onset shift and recognition (r = 0.20; p < 0.05; n = 97), indicating a shift to left dominance at that time. Examination of the Figure shows a clear reversal and continued separation between the EEG patterns for high- and low-recognition components. The divergence between the high and low memory groups was greatest at t = 3 (p < 0.05).

Rival Hypotheses

It was possible that the memory scores were related to factors other than the electrical patterns occurring at the time of exposure. One rival hypothesis could have been that the goodness of memory was tied to the length of the commercial component; however, there was no correlation (r = -0.02; n.s.; n = 95) between the length of the commercial component and its memorability. Another unfounded rival could have been that memory was tied to the type of recognition test stimulus. There was only a marginal difference between the memory scores on the verbal versus the visual tests (t = 1.45; p < 0.10). The influence of visual hemifield upon dominance EEG patterns also could have been a plausible rival hypothesis if the test stimuli were print ads, but given the nature of television viewing, this issue does not seem to have been relevant to this study.

DISCUSSION

This study was undertaken to investigate the relationship between EEG and memory. Prior advertising-related studies in this area have shown inconsistent results when the unit of analysis was the entire commercial. This inconsistency was felt to be unusual given (1) the strength of the relation of changes in EEG to changes in the message and (2) the more basic physiologic findings that showed a relation between EEG and memory when the stimuli were simpler and shorter.

By changing the unit of analysis, the present study showed data that were more consistent with the prior findings of positive relations. According to these findings, those components that were remembered well were more likely to exhibit a longer period of alpha blocking and a delayed period of left hemisphere dominance. Components that were remembered poorly were more likely to show more rapid attenuation of power to a higher resting level and a delayed period of right hemisphere dominance. These findings were consistent with what the EEG literature would predict, based on responses to simpler and shorter stimuli.

For the most part, the basic findings seemed to hold in the complex environment. They held well for the post-onset periods, but less well for the onset periods. During the onset period, there was a shift to the right hemisphere indicative of an increase in the vigilance necessary for later learning to take place, but the predicted drop in overall alpha power did not take place. Perhaps the relative weakness in the onset period pattern stemmed from the complexity of the environment. Since the subjects were already processing prior to the onset period, there may have been little additional blocking that could take place. This is supported by the relatively high attenuated power levels that resulted in the post-onset period for the low memory condition. Perhaps lack of attenuation in the pre-onset periods (due to prior stimulus components) precluded the possibility of significant alpha blocking in the onset periods.
Even though total power (indicative of blocking) did not change from the pre-onset to the onset period, there still was a shift to the right hemisphere during the onset period in definable cases. There was heightened vigilance in response to the first second of the component even though there was no change in power. In those cases where the resultant memory was high, there was an observable change in the dominance pattern of processing.

The post-onset period was more clearly influenced by the component to which subjects had been most recently exposed. Here the processing patterns were more similar to those found in the earlier studies with simpler stimuli, and both of the hypothesized processing changes were observed. When learning was taking place, there was a longer period of alpha blocking, and this later blocking shifted toward left hemisphere dominance. There were significant differences in the electrical patterns between those components that were remembered well and those that were remembered poorly.

Perhaps the post-onset data were clearer because there was less opportunity for a confound from the prior component at this time. When the target component first began, subjects may have been still processing the prior component. It may be that subjects were forced by the continuously evolving nature of the message to begin to evaluate the new component and shift attention to it in a rapid manner. As the target component continued, subjects shifted focus to the new component. When this was done well, either because the subject was an efficient processor or because the target component was captivating, then the proper electrical patterns developed as a manifestation of efficient processing that would lead to measurable learning. When this was done poorly, the subject returned to, or remained in, a vigilance state and did not learn the new component.

Most current information processing work exposes a subject to a stimulus (for example, a 30-second television commercial) and then asks for retrospective and introspective assessment of the processes that took place within the subject. Furthermore, these evaluations are based on constructs and questions imposed by the researcher upon the subject. The data presented here suggest that an enormous amount of information processing occurs during a 30-second commercial and that processing cannot be completely addressed via introspective and/or retrospective assessment of hypothetical constructs. By considering arousal and memory only at the macro level, too much information is lost. The work presented here should lead to a reassessment of some of the basic concepts of information processing as practiced in consumer research.

It is time to pursue the new field of micro information processing. Currently, several researchers are working with physiologic tools and units that are smaller than the entire message. Although other tools can provide insight to processing also, the EEG has the richest potential, for it can be observed at multiple locations on the scalp and at multiple electrical frequencies at each location. Interpretation of this richer data set may ultimately lead to a better understanding of information processing and learning.

We have not found any other work that links EEG to memory in cases of complex stimuli. Neither the EEG nor the memory literature contains this type of work, and perhaps the greatest contribution of this work to these areas is methodologic. Knowledge of the relationship between EEG, information processing, and memory is not new, but the ability to show these relationships with complex stimuli over time is new. While the simple stimuli used in earlier studies represent static presentations, the current work examines a dynamic stimulus unfolding with the passage of time.

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