VERBAL CREATIVITY, 40Hz. AND THETA

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ABSTRACT

Verbal creativity was hypothesized to be correlated with right hemisphere primary processing in theta and left (speech) hemisphere secondary processing in the 40Hz. EEG rhythm. Twenty-two students were administered the Torrance "Thinking Creatively with Words" instrument while their brainwaves were monitored and digitally scored. Creativity score/frequency count Spearman rho coefficients were calculated for (a) resting baseline activity, (b) creative activity only, (c) creative plus baseline activity, and (d) percent shift (baseline to creative activity). Correlation of creativity score with left hemisphere 40Hz. activity for the above four measures were, respectively: .46 ($p<.01$), .56 ($p<.01$), .46 ($p<.01$), and .28 (n.s.). For left side theta the respective correlations were: -.19 (n.s.), -.28 (n.s.), .28 (n.s.), and -.14 (n.s.). For the right hemisphere, the respective correlations were: for 40Hz. .53 ($p<.01$), .35 (n.s.), .52 ($p<.01$), and -.38 (n.s.), for theta: -.09 (n.s.), -.06 (n.s.), -.08 (n.s.), and -.02 (n.s.). Creativity score extreme groups showed high group mean baseline to creative activity shifts toward more left side 40Hz. and less right side 40Hz. and an opposite but smaller low group trend. Both groups in both hemispheres shifted to more theta and more so in the right than left side.

PROLOGUE

Life without fantasy is a seriously impoverished life.

- Jerome Singer

In order to maintain mental stability and psychological health, man must integrate the irrational, instinctive portions of his personality with his rational, intellectual side.

-Carl Gustav Jung

Those who allow themselves to be irrational at times will never become stuffy or dull. They will be opening up the channels through which the formative and intelligent spontaneity of the organism can blow into consciousness.

-Alan Watts

INTRODUCTION

Physiological correlates of creativity are rare and those that have been offered have mostly been quite divorced from the traditional creativity theorists. The present study sought to correlate verbal creativity (creativity and verbal processing) with two types of thinking proposed by creativity theorists and assumed to be represented by lateralized electrocortical activity of the right and left hemispheres.

As a psychological variable, creativity has been investigated with various instruments utilizing different types of operational definitions such as originality in guessing consequences, simile construction, etc. It has been associated with slow theta brain wave rhythms (Green, 1972) and although inversely related to anxiety (Jenkins, 1960, Horton,

et.al., 1963, Krop et.al., 1969, and Dentler and Mackler, 1964) some forms of creative inspiration would appear to be accompanied by a high state of arousal as would be depicted in the caricature of a Beethoven or van Gough. Also, focussed attention would be necessary for reality-oriented expression. These may suggest that creativity, especially of the verbal variety, would involve two component functions: 1) relaxed, slow wave periods or places where sensory patterns and thoughts intermix and combine resulting in a twilight state where novel ideas arise, and 2) alert, fast wave, directed thinking in a learned complex, logical, linear mode, categorizing verbally for the expression of novel ideas.

Definition of Creativity:

Taft (in Gowan, 1972) talks about primary process "hot" and secondary process "cold" thinking:

> "The primary process creativity occurs in the preconscious and the secondary process required more controls and less fantasy expression, such as scientific investigation."

Hallman, (1967) defines creativity as a fluid shifting between psychic levels, referred to by various researchers as primary-secondary, autistic-reality adjusted, unconscious-conscious, free and bound energies, and gestalt-free and articulating tendencies.

Hemispheric Lateralization and Creativity

The idea that the creative process calls for propositional and appositional thinking would indicate some relationship between creativity and lateral asymetry of brain functions. Bogen and Bogen (1969) describe the relationship saying "Specialization of the hemispheres for different modes of thought greatly increases the flexibility and creativity of the ensemble". Their observations "suggest that integrated use of verbal and visuo-spatial thought may be dependent on interhemispheric communication, including an important contribution from the corpus callosum". They relate their observations to a statement by Ruesch and Kees (in Bogen and Bogen, 1969): "The writer depends necessarily upon evoking nonverbal images to verbal means..." and Spender's (in Bogen and Bogen, 1969) description of poetic invention", ... a dim cloud of an idea which I feel must be condensed into a shower of words". And finally, in Einstein's (also in Bogen and Bogen, 1969) description of his own creativity,

> "The physical entities which seem to serve as elements in thought are certain signs and more or less clear images.... in combinatory play.....
> The above-mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage, when the above-mentioned associative play is sufficiently established and can be reproduced at will....."

In discussing the lack of creativity Bogen and Bogen see transcallosal

inhibition as a physiological basis "for the fact that failure to develop fresh insights (in the sense of new understanding of the outside world) is closely related to a failure to gain further insight into one's other self". A prime example of this is the antagonism between intuition and analysis which for Western man has resulted in the inhibition of the appositional mode, and the excess of propositional thinking. "Life without fantasy is a seriously impoverished life, (and) the dominant cultural patterns of Western Civilization tend to discourage this mode of experience. (Singer, 1965)

Studies of hemispheric localization of brainwaves (Peper, 1972) have shown that right side alpha could be produced by a subject relaxing, singing to herself, and feeling a rhythm of dancing. Left side alpha was produced by the subject spelling words, naming states and multiplying large numbers. If creativity involves both hemispheres and different frequencies simultaneously, localization or frequencies may or may not appear.

Hypnagogic Imagery, Theta, and Creativity

Elmer Green is probably the foremost author suggesting that creativity stems from hypnagogic imagery and correlating both with theta (4-7Hz.) brainwave activity. The classic example is that of the genius gaining insight during reverie. Budzynski (1972) speaks of disintegration of the reality-oriented frame of reference and the lowering of certain defenses as relating to creativity as well as suggestibility, hypnotizability, and pre-sleep learning. In one of Green's (1972) studies it was found that demonstrably creative people (a psychiatrist, a psychologist, and a professor of physics) show a high percentage of 6½-8Hz. activity indicating a slowing alpha and an increase in theta over a relaxed, alert EEG pattern. According to Martindale and Armstrong (1974) "Empirical research by Wild (1965), Fitzgerald (1966), and Gamble and Kellner (1968) has revealed a correlation between creativity and access to primitive modes of thought". All of these studies are based upon Ernst Kris (1952) idea of regression in service to the ego. In another study, Stembridge (1973) enhanced performance on various creativity measures in subjects with practice in free association while in an experimentally induced hypnagogic state.

Forty Hertz and Creativity

It has been demonstrated (Sheer, et.al., 1970) that acquisition learning and orienting behavior are accompanied by high frequency (35-40Hz.) EEG activity in Cats. Relationships also have been established (Hix, 1971, Bird and Newton, 1975) between high brainwave frequencies and verbal and nonverbal learning tasks and problem solving in humans. If acquisition of language task abilities in humans is meditated by focused attention and consolidation occurs with high frequency brainwaves, then, assuming

state specificity, fast frequencies and focused attention would be necessary for retrieval in verbal creativity.

Low and high frequencies may correspond to the primary-secondary thinking, continuous fluid shifting referred to by the creativity theorists. Martindale and Armstrong (1974) connecting data from Rapaport (1957), Lindsley (1960), Blum (1961), and Daws (1966) "translate Kris' formulation into the hypothesis that creative persons posses an above average ability to shift among various levels of arousal". They tentatively prove this hypothesis by showing that more creative subjects are better able to control their alpha rhythms with biofeedback techniques yet don't take hemispheric lateralization into account. Also, different frequencies may occur simultaneously as was the case with Swami Rama. Green (1972) reports that when the Swami demonstrated that he could remain conscious while producing delta waves (normal sleep rhythms, 1-4Hz.) the EEG pattern showed delta, theta, alpha, and beta rhythms all during the same period. If creativity involves simultaneous high and low frequencies localized in different hemispheres then the evidence that creativity involves the ability to shift among various levels of arousal would be complimented by Bogen and Bogen's idea that transcallosal inhibition is responsible for the lack of creativity.

Creative thinking may involve active processing in combination with a different type of processing which might be labeled passive receptive processing. The passive processing would consist of bits of reality-oriented symbols, phrases, images, etc. which would be jumbled up and arising spontaneously in awareness. This type of processing would be correlated with lowering of defenses and disintegration of ego boundaries associated with hypnagogic imagery and dreaming states and accompanied by the slower brain rhythms, alpha, and theta. This "random" thinking could be monitored by a simultaneous active processing which sort out the relevant or usable products of the passive processing and code, store, and process them for expression (via the speech hemishphere for verbal creativity). This active processing would involve the faster brain wave frequencies of beta and forty Hz. activity.

It would be reasonable to assume that hemispheric lateralization of these simultaneous functions would result in greater efficiency of the ensemble (Kinsbourne, 1971). It is hypothesized here that in verbal creativity, hypnagogic imagery would arise with the right hemisphere in theta and alpha while the left (speech) hemisphere, actively processing at fast frequencies, would take the relevant images and put them into verbal expression. Simultaneous functioning would be most efficient because if the images are not immediately processed they are more likely to slip out of awareness and be lost.

EXPERIMENTAL DESIGN

Twenty-two persons were given a modified form of the Torrance Test of Creative Thinking ("Thinking Creatively with Words") Form A (Torrance 1966) while their brain wave activity was monitored.

Subjects

Subjects were selected from volunteers from the University of Houston; most of whom were from an introductory psychology class, while several were from higher level courses and two were graduate students in psychology and social work. Balanced for sex, their ages ranged from 18 to 55 years with several being over 30, including one retired prison warden. All subjects were English speaking, native Americans.

Creativity Test

E. P. Torrance's "Thinking Creatively with Words" was selected for a measure of creativity because of its ease of administration and scoring, adaptability for an EEG Study, and for its generally good references as a reliable and validated instrument (Burres, 1973). The test consists of seven activities soliciting various subject responses such as asking unusual questions, guessing consequences that no one else would guess, etc. The scoring of the instrument is based upon statistical infrequency of each response and each type of response. Five of the activities have a time period of five minutes and two activities last ten minutes. Four of the five minute activities were used (two for recording from each side of the head) and were modified for EEG recording. It was necessary to

reproduce accompanying illustrations in slide form so they could be projected upon the wall thereby enabling the subjects to lie back and relax in front of a constant visual stimulus with eyes open for a uniform period of time for all activities. In administering the instrument it was necessary to break each activity into a thinking period and a writing period to avoid the high voltage, high frequency, overriding muscle activity involved in holding the head up and in writing. For each of the activities, subjects were given a three minute period to think of responses and mentally put them into words as if they were writing them down (otherwise, they would typically wait until the writing period to formulate sentences from their ideas, as happened in pilot studies). During the thinking period, EEG recordings were made. For the writing period, subjects were to take as long as needed to write down everything they thought of during the thinking period without adding any new ideas occurred while writing the previous ones down.

Procedure

During the three minute thinking periods, EEG recordings were taken alternately on both sides of subjects' scalps at O_1-C_z and O_2-C_z for theta and 40Hz. activity. Digital counters recorded one count for each three cycle burst for each of the frequencies at minimum amplitudes of 75μv for theta and 8μv for 40 Hz activity. Recordings were taken at temporal and neck muscles which provided muscle activity controls. When muscle and head 40 Hz. were coincident, it was assumed that muscle activity was overriding EEG activity and with the use of coincidence detection units (comparators) the 40Hz. burst for that epoch was not registered on the digital counters. Thus 40Hz. activity was registered only when it occurred not coincident with muscle high frequencies. (For more about this control procedure see

Sheer, 1970). Recordings were made with standard grass electrodes and a 10-channel Model 78 grass polygraph with amplifiers at or close to maximum sensitivity.

The four test activities, Asking Questions, Guessing Consequences, Unusual Uses of Cardboard Boxes, and Just Suppose, were administered in the normal order to all subjects and were counterbalanced for later comparison by recording half the subjects' EEG first on the left side of the head then on the right and the remaining subjects in the reverse order.

Two baseline EEG measurements were taken on each side of the head for a total of four. Two were taken at the beginning on one side of the head and two were taken at the end on the other side of the head. There were two types of baseline taken -- active and passive with one of each taken before and after the creativity task. The active baseline was instigated to gain some measure of control over subjects' thought processes and consisted of recordings done while the subject mentally counted backward from 1000 for three minutes. Passive baselines consisted of recording for three minutes while subjects only relaxed with eyes open, as before, without counting.

RESULTS

No differences showed up in the counts for the active and passive baselines therefore they were averaged for comparison with the activity period recordings. Adjustment of the baseline counts was necessary, however, for the post baselines on both sides of the head for theta frequencies as there was a 30% greater count on the post than on the pre-task baselines regardless of which side of the head was recorded last. This was considered a fatigue factor due to the strenous mental activities which composed the creativity instrument. There were no such differences in the high frequency baselines (the last exceeded the first by 5% for the 40Hz.

baselines). Also no such differences were evident for activity counts between the first and last activity periods for either frequency.

Spearman rank order correlation coefficients (rho) were calculated between creativity scores (sums of the scores for the four tasks) and theta and 40Hz. EEG activity. In the correlation table (Table I) are values for four types of correlation: (a) Baselines, (b) Activity Only, (c) Activity + Baseline, and (d) Percent Shaft from Baseline to Activity $\left(\frac{\text{Activity - Baseline}}{\text{Baseline}}\right)$. Significant correlations were found in the 40Hz. frequency in the left hemisphere for the activity only counts and for both hemispheres in the baseline and activity + baseline counts. A near significant correlation appears for right hemisphere 40Hz. activity. Also there seem to be percent shift trends with the negative correlation of rho = -.38 in the non-speech hemisphere (an apparent contradiction which is explained in the next section) and the almost significant rho = .28 in the left hemisphere.

For theta, trends appear in the negative correlations indicated in the left hemisphere activity and baseline and activity + baseline correlations and in the overall activity + baseline correlation. It should be noted however, that the right hemisphere theta shows no such trends.

From a different perspective on the data, the table of means (Table II) shows the mean frequency counts for high and low extreme groups (n = 10) according to creativity scores and their mean percent and direction of shift from baseline to activity. Although percent shift correlations were not significant in general (as there were anomolous shifts and creativity scores) the shift counts especially in theta, indicate that on the average there is a shift towards more theta when a subject is presented

TABLE I

FORTY HZ. AND THETA FREQUENCY COUNT/CREATIVITY SCORE

SPEARMAN RHO CORRELATION COEFFICIENTS

		40Hz. rho	p	theta rho	p
Baseline	Left Side	.46	.01	-.19	n.s.
	Right Side	.53	.01	-.09	n.s.
	Overall	.49	.01	-.24	n.s.
Activity	Left Side	.56	.01	-.28	n.s.
	Right Side	.35	n.s.	-.06	n.s.
	Overall	.57	.01	-.15	n.s.
Activity + Baseline	Left Side	.46	.01	-.28	n.s.
	Right Side	.52	.01	-.08	n.s.
	Overall	.59	.01	-.38	n.s.
% Shift $\frac{(\text{activity-baseline})}{\text{baseline}}$	Left Side	.28	n.s.	-.14	n.s.
	Right Side	-.38	n.s.	-.02	n.s.
	Overall	-.15	n.s.	.09	n.s.

TABLE II

TABLE OF MEAN THETA AND FORTY HZ. FREQUENCY COUNTS OVER A THREE MINUTE PERIOD FOR HIGH AND LOW CREATIVITY SCORE RANKED EXTREME GROUPS (N=10) WITH BASELINE TO ACTIVITY PERCENT AND DIRECTION OF SHIFTS

(→ indicates up shift, ← indicates down shift)

		Right Side			Left Side		
		Baseline	% Shift	Activity	Baseline	% Shift	Activity
FORTY HZ.	High Creativity Group (1 - 10)	238	38% ←	148	160	35% →	215
	Low Creativity Group (13 - 22)	79	14% →	90	127	8% ←	117
THETA	High Creativity Group (1 - 10)	68	117% →	148	113	44% →	162
	Low Creativity Group (13 - 22)	105	65% →	173	158	48% →	234

with a verbal creativity task and more so in the right than in the left hemisphere regardless of how high or low the performance on the task. Also worth nothing, in the high performance group, there is an average down shift in 40Hz. in the right hemisphere and an up shift in the left hemisphere -- a trend which is reserved (although slight) in the low performance group.

DISCUSSION

Apparently 40Hz. activity is correlated with verbal processing involved in the Torrance instrument "Thinking Creatively With Words", and although the baseline correlations are strong for both hemispheres it is somewhat localized in the speech hemisphere which might account for the relative down shift trend in the non-speech hemisphere. If slow frequency processing is occuring it is thus far indistinguishable from the ordinary resting state. Whether the images are arising or not, without verbal processing they are not expressed. According to Martindale and Armstrong (1974) "The Research of Pine (1959) and Pine and Holt (1960) on verbal productions of high and low creative subjects shows that the former differ from low creative subjects not so much in presence or primary process material but in integration or secondary process binding of this material".

It seems likely, taking into account the creativity theorists' position and the data from the biofeedback induced twilite state research on the lowering of defenses and dissolution of ego boundaries being an integral part of the creative process, that a type of processing is going on with the lower frequencies in the non-speech hemisphere. That is, a passive receptive processing of ideas and images and symbolic transfor-

mations which is reality oriented in that it is made up of bits of reality perceptions which are jumbled up and which appear "randomly" or without seeming formal structure in awareness. Perhaps as the "random" thinking occurs in one side of the brain with slow frequencies, relevant combinations of ideas of symbol transformations are picked out by fast frequency processing either: 1) in the speech hemisphere which may actively code the relevant spontaneous thinking which may then process for verbal expression, or 2) perhaps a loose organization is accomplished in the relatively slow frequency hemisphere actively processed with the fast frequencies which remain there into a code which can be transferred to the fast frequency verbal processing hemisphere. Such coding in the relatively slow frequency hemisphere would serve to keep the hypnagogic imagery from slipping away before it could be put into words. Such may be the cause for the near significant correlation of creativity scores with the fear frequencies in the right hemisphere. For verbal creativity a near significant downshift in 40Hz. may occur to allow for slow frequency processing while near significant amounts of 40Hz. remain present to grasp the products of slow frequency processing.

From the data it seems feasible to say that both 40Hz and theta activity are related to verbal creativity but that the relationship is not simple and although they tend to be localized in the left and right hemispheres respectively, there are mitigating factors which cause the two frequencies to be somewhat present in the contralateral hemispheres. Perhaps active processing is necessary to "corral" the primary process imagery in the right hemisphere. Also, if the tendency is for theta in the left side to correlate negatively with creativity the question arises as to why both high and low scoring groups would tend to shift into theta in that hemisphere.

Non-verbal Creativity

Non-verbal creativity of non-speech hemisphere creativity involving holistic or spatial processing such as in some visual arts may show the reverse left-right frequency relationships and shed more light on the relationships in general. The Torrance instruments "Thinking Creatively With Pictures" may provide a good measure for such research.

Computer Models of Creative Thinking

The creativity/frequency relationships demonstrated with two types of thinking suggested may offer implications for computer models of creative thinking. The possibility arises of a crude type of creative thinking machine with a random fact, phrase of image generator, a mizer to transform and recombine elements, and a sorting device to pick out combinations relevant to a given problem.

SUMMARY

Creativity theorists have postulated two types of thinking involved in the creative process. Primary process thinking has been associated with dissolution of ego boundaries, lowering of defenses, hypnagogic imagery and slow brain rhythms. Secondary process thinking involving alert, orderly processing for expression in a learned mode has been linked to fast frequency brain rhythms. For verbal creativity it was hypothesized that primary processing, slow frequencies would be localized in the right hemisphere and secondary processing, fast frequencies would be localized in the left. Twenty-two persons were administered the Torrance instrument "Thinking Creatively With Words" (modified for EEG recording) while their brain waves were monitored. Fast frequencies (40Hz.) during the activities correlated with verbal creatively at rho = .56 (p .01) for the left hemishpere, rho = .35 (p .2) in the right hemisphere and rho = .57 (p .01) for both hemispheres combined. Baseline 40Hz. correlations were significant (p .01) for both left and right hemispheres at rho - .46 and .53 respectively. For activity + baseline, 40Hz. correlations for left, right and overall (rho = .46, .52, .59, respectively) were significant at the p .01 level. For fast frequency percent shift from baseline to activity correlations with creativity scores, the left side upward though not significantly so (rho = .28, p .2), the right side tended toward a down shift with rho = -.38 (p .01) and the overall shift correlations was not significant (rho = -.15).

For slow frequencies there was a tendency toward negative correlation (rho = -.28, p .2) in the left hemisphere, but non-significant correlations in the right side (rho = -.06) and for the two sides combined (rho = -.15). Baseline theta correlations for left side, right side and overall were not signigicant at rho = -.19, -.09, and -.24 respectively. For

activity + baseline correlations, there was a tendency toward negative correlation of slow frequency with verbal creativity in the left side, although not significantly so (rho = .28, p .2). For right side slow frequency/creativity scores, rho equaled a non-significant -.08. Overall there was a near significant negative correlation of rho = -.38, p .01). Percent shift correlations for the slow frequency were non-significant for left side (rho = -.14), right side (rho = .02) and overall (rho = .09).

A table of means for creativity score extreme groups of ten showing mean percent shift from baseline to activity revealed that high creativity scorers tended to shift toward more 40Hz. in the left (speech) hemisphere and less 40Hz. in the right hemisphere while the low creativity score group showed the opposite trend to a lesser degree. The table also showed that both groups tended to shift into more theta for both hemispheres and more so in the right than in the left hemisphere.

From the data it appeared that both 40Hz. and theta were related to verbal creativity but not simply and directly. Although the fast and slow frequencies were somewhat localized in the left and right hemispheres respectively, each still appeared to a significant degree in the other side.

It was suggested that the reverse frequency relationships may be evidenced for non-verbal hemisphere creativity and that research in that area might shed more light on the brainwave/creativity relationships. Implications for a computer model of creative thinking were also discussed.

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