Theta Rhythm Production and Creativity Through Simultaneous Sensory Stimulation

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Abstract

The purpose of this research was to investigate the effects of simultaneous sensory stimulation (SSS) on theta production and creativity. The hypotheses being tested were: 1) subjects' amount of theta production would be greater following SSS than following neutral stimulation (NS); 2) subjects receiving SSS would be more able to gain control over theta production than subjects receiving NS; 3) subjects exposed to SSS would increase in measures of creativity.

Forty first year university students (20 males and 20 females) were divided into four groups with five males and five females in each group. Group 1 received SSS and theta feedback. Group 2 received SSS and no theta feedback. Group 3 received NS and theta feedback. Group 4 received NS and no theta feedback.

Simultaneous sensory stimulation consisted of visual, auditory, olfactory, somasthetic, thermal and gustatory stimulation for a period of 15 minutes. Neutral stimulation consisted of a 15 minute taped lecture on thinking. Prior to SSS or NS all groups were administered a creativity pretest (Torrance Tests of Creative Thinking). Immediately after SSS or NS all groups were monitored for theta production for four 50 second intervals. Immediately after the monitoring session all groups received a twenty minute feedback/no feedback session which was divided into six 200 second intervals. An auditory signal was presented as feedback for theta production. The no feedback group received no signal. Immediately following the feedback/no feedback session all groups received a posttest of the Torrance Tests of Creative Thinking.

A main effect of stimulation was found in the monitoring session, $p < .01$, and persisted into the feedback session, $p < .01$, thus supporting the first hypothesis. No interaction of stimulation and feedback was found which did not support the second hypothesis. No significant changes in creativity were found. Hence, the third hypothesis was not supported. However, a main effect of feedback, $p < .05$ (one-tailed), was found. This effect of theta feedback was found to allow subjects to more effectively maintain theta production rather than to increase theta production. An interaction between stimulation and sex on the feedback data, $p < .05$, was also found, possibly due to differences between males and females in hemispheric activation during self-regulatory tasks.

Theta Rhythm Production and Creativity through Simultaneous Sensory Stimulation

Research in biofeedback has undergone tremendous growth over the past decade particularly because of the possibilities for enhanced self-control. This aspect of voluntary control is important for the <u>subject</u> experiences himself as the locus of control and through an act of choice can demonstrate control over his internal states. Davidson and Krippner (1971) suggested that "with the application of biofeedback techniques, large numbers of people can evolve into more integrated beings, who are less subject to manipulation and more inner-directed" (p. 19). Basically the feedback technique involves providing the <u>subject</u> with continuous information about a specific physiological functioning. From this information the <u>subject</u> is then able to identify the desired state and, in many cases, produce the desired change.

Through biofeedback techniques subjects have learned to control such physiological functions as heart rate (e.g., Weiss and Engel, 1971), blood pressure (e.g., Shapiro, Tursky and Schwartz, 1970), skin resistance (e.g., Kimmel, Pendergrass and Kimmel, 1967), muscle tension (e.g., Budzynski and Stoyva, 1972) and brain waves (e.g., Brown, 1970).

Self-control of these functions has numerous implications in the areas of cardiovascular therapy (e.g., Shapiro and Schwartz, 1973), muscle tension (e.g., Budzynski and Stoyva, 1972), headaches (e.g., Budzynski, 1973; Sargent, Green and Walters, 1973), anxiety (e.g., Raskin, Johnson and Rondestvedt, 1973) and epilepsy (e.g., Sterman and Friar, 1972). Biofeedback may prove useful in changing not only physiological events but perhaps also those of an experiential nature. Subjective states of consciousness can now be studied by combining verbal reports and physiological measures, brain rhythms in particular. Further, it may be possible to provide the means for people to produce physiological conditions favorable for the appearance of certain kinds of mental activity (Stoyva, 1971).

The four main classes of brain rhythms, each labelled with a Greek signature letter, have been generally associated with certain types of mental activity. Duffy (1962) suggested that the electroencephalographic (EEG) pattern represents an activation continuum with alpha (8-13 c/s) and theta (4-7 c/s) appearing between two extremes of arousal or excitation, beta (over 13 c/s) and delta (1-3½ c/s).

Beta, the fastest rhythm, has generally been associated with nervous tension, mental concentration, attention and orientation (Lawrence, 1972). At the other end of the continuum, delta has been found dominant in infants up to one year of age and to be associated with deep sleep in the normal adult. Alpha, the most striking component in the normal adult EEG, is generally associated with a relaxed yet alert mental state (Lawrence, 1972). A number of studies have already demonstrated that the amount of alpha activity in the EEG can be increased through biofeedback procedures (e.g., Kamiya, 1968; Nowlis and Kamiya, 1970). Theta rhythms are the dominant wave in children two to five years of age. Throughout the second decade these waves diminish in the waking state (Pond, 1963). Because of the scarcity of theta in the waking EEG, the prime interest of many researchers and of this research is that of theta induction so that the states of awareness that are associated with the conscious control of theta rhythms can be examined.

It has been noted that a relationship appears to exist between theta production and the awareness of hypnagogic imagery (Green, Green, and Walters, 1970). It has also been noted that this hypnagogic imagery seems to correspond with descriptions given in a number of introspective accounts of the creative process.

Taylor has demonstrated that a procedure known as simultaneous sensory stimulation (SSS) can be a significant factor in developing and facilitating creativity in normal populations (Taylor, 1972) as well as gifted young adults (Taylor, 1970) and chronic schizophrenics (Taylor and Knapp, 1971). It may be postulated that SSS induces theta, thus facilitating creativity. If so, it may be possible through biofeedback procedures to prolong theta production.

The purpose of this experiment, then, was to investigate the effects of SSS in terms of theta production and creativity.

Since SSS facilitates creativity and since theta production is related to the awareness of hypnagogic imagery which, in turn, appears to be related to the creative process, it was hypothesized that (1) the _subjects_' amount of theta production would be greater following SSS than following neutral stimulation (NS).

It has previously been found that once theta production is at a sufficient level to be detected, the state can be prolonged by continuous feedback (Budzynski, 1972). The second hypothesis, therefore, was that (2) _subjects_ receiving SSS would be more able to gain control over theta production than _subjects_ receiving NS, that is, an interaction between stimulation and feedback was predicted.

The third hypothesis was that (3) subjects exposed to SSS would increase in measures of creativity. Although this has already been found by Taylor (1972), it was investigated in this study to determine if increased theta production is associated with increased creativity.

Theta Research

Although little theta is evident in the normal adult waking EEG, it has been found to be the precursor of sleep (Rechtschaffen and Kales, 1968, cited in Budzynski and Stoyva, 1972). Hence, theta has been associated with sensations of drowsiness and warmth occurring just prior to sleep. Theta appears in the lowest arousal state one can maintain while still being awake. With the onset of theta rhythms in the EEG, other physiological changes also occur. Sittenfeld (1972) noted a marked and sudden drop in the frontalis electromyograph (EMG) and heart rate with the onset of higher theta activity. Gastaut (1969) also noticed a diminution of tonic muscular activity. Timmons, Salamy, Kamiya and Girton (1972) found that a reduction of the amplitude of abdominal movements occurred with 93 percent of the transitions from alpha to theta and an enhancement of abdominal amplitude with 81 percent of the transitions from theta to alpha.

Theta has also been found to relate to certain introspective states. In Brown's (1970) study concerning subjective experience of brain wave frequencies, the greatest difficulty in formulating an adequate unifying description occurred with theta activity. However, those who did define feelings related to theta activity indicated its association to the general mental activity of problem solving or orienting in the sense of adjusting to the surroundings. Luce and Segal (1967) have suggested that the theta rhythm may be produced when the individual becomes inward, immersed in his own feelings and memories, and is least able to incorporate a great deal of outside information. In Green, Green, Walters, Sargent and Meyer's (1975) study all <u>subjects</u> learned to consciously increase their percentage of theta production and all of the <u>subjects</u> producing theta reported large increases in awareness of hypnagogic (or hypnagogic-like) imagery. This imagery often contained "answers from the unconscious" and many <u>subjects</u> had experiences that could be called "personally integrative". In Green's (1972) work with Swami Rama, an Indian yogi, the Swami produced theta by "stilling the conscious mind and bringing forward the unconscious" (p. 163). The Swami indicated that theta was an unpleasant state and "very noisy". It has also been noted by other researchers that theta is occasionally accompanied by unpleasant feelings of anxiety (Walters, 1953; Luce and Segal, 1967).

Due to the scarcity of theta in the alert person's EEG and its general association with a disconnected mental state, the control of theta is often difficult. To overcome this problem, various induction techniques have been proposed. Budzynski and Stoyva (1972) first gave subjects EMG feedback for deep muscle relaxation, since muscle relaxation is frequently associated with a spontaneous increase in theta production. The subjects were then shifted to the feedback of theta itself.

Another method of increasing theta production to a sufficient level so as to gain control over its production was suggested by Timmons et al. (1972). They suggested, from their research involving theta and abdominal amplitude, the self-manipulation of respiratory patterns may be useful for increasing the amount of theta production. Accordingly, one of the main exercises suggested by Swami Rama to Elmer Green for increasing theta production "consisted of deep and slow rhythmical breathing at a constant rate both in and out, with no pauses at the bottom or top of the respiration cycle" (Green, 1972, p. 165).

In research involving sleep-onset, techniques of mild sensory deprivation were used for induction purposes. Henri Gastaut (1969) had his subjects read from a book until they fell asleep. Beta frequencies predominated until the subjects stopped reading, at which point steady alpha appeared. Soon thereafter a fragmented alpha pattern appeared only to be replaced by low voltage theta. Bertini, Lewis and Witkin (1969) developed a technique to induce sleep-onset by generating a monotonous white noise and using "ganzfeld" glasses to produce a homogeneous visual field. They found that this mild form of sensory deprivation enhanced the production of hypnagogic imagery. Other researchers in the area of sensory deprivation have noted the occurence of visual hallucinations as well as slowed brain rhythms (Shultz, 1965). Budzynski (1972) suggested using similar techniques for the purpose of inducing theta.

Sensory Stimulation

Another technique which may be useful for the induction of theta is sensory stimulation. A similarity of the previous techniques used to induce theta and/or hypnagogic imagery is a reduction in the level or variety of external sensory input to the brain. Sensory stimulation, in contrast, would involve an increase in the amount of external sensory input to the brain. These two, seemingly opposed, techniques can be unified by the concept of optimal stimulation. Forehand and Baumeister (1970) have summarized this concept as follows:

> As auditory-visual stimuli increase, the need for proprioceptive stimulation decreases accordingly. Therefore, by increasing activity during conditions of reduced stimulation, the organism approaches optimal stimulation and by decreasing activity during increased stimulation, the organism prevents excessive stimulation. (p. 472)

According to West (1971) "when effective (attention commanding) sensory input decreases below a certain threshold, there may be a release into awareness of previously recorded perceptions through the disinhibition of the brain circuits that represent them" (p. 269). Conversely, it was proposed here that when sensory input is increased to a certain level, there may be an inhibition of neural activity. These two techniques, reduced and increased sensory input, may, then, produce similar results.

Although sensory stimulation may appear to be the "opposite side of the coin" in comparison to sensory deprivation (Ludwig, 1971), the contrast may not be as clear as it appears. Sensory deprivation studies attempt to reduce sensory stimulation (and input) to as low a level as is possible, that is, to an absolute minimum (Shultz, 1965).

Sensory stimulation, in contrast, can be operationalized in a number of ways due to the fact that sensory stimulation is defined by a number of dimensions. The three most basic dimensions are modality, intensity and value (pleasant vs. uncomfortable). For example, sensory overload, as defined by Lindsley (1961) refers to the stimulation of two or more sense modalities at levels greater than normal. Sensory stimulation of this type (sensory overload), has been found to result in excessive cortical arousal (Kitamura, Hatayama and Saito, 1972; Komatsu, Kawata and Shimada, 1972; Hatayama and Komatsu, 1972). Sensory overload has been found to produce mild to profound hallucinatory experiences in 40 percent of the population (Ludwig, 1971). Haer (1971) found that altered states of consciousness produced by sensory overload were positively associated with field dependence. According to West (1971), "the functions of consciousness apparently reach an optimal point in relation to the level of arousal, beyond which they disorganize progressively as arousal increases excessively" (p. 270). Haer (1970) found that after exposure to sensory overload there was a change in thought processes, that is, a slowing down of thinking. Gottschalk, Haer and Bates (1972) also found an increase in cognitive impairment after exposure to sensory overload. The subjective experience of the state experienced after exposure to stimulation was of a drifting, reverie-like quality (Haer, 1970), similar to that which accompanies an altered state of consciousness. The subjects' thoughts after exposure seemed to be restricted to the immediate present rather than the future or the past and they felt tired or disinterested in getting on with their daily routine. Half of the subjects also felt more integrated, "concentrated" or "pulled together" as a result of the experience. Also, Taylor (1976) found that "subjects became more confident, more spontaneous, less intellectualizing and reported feelings of 'expansiveness', involvement and feelings of euphoria" following exposure to simultaneous sensory stimulation (SSS). These subjective reports bear similarities to those expressed by subjects in Green's et al. (1975) experiment concerning the effects of theta conditioning.

The purpose of this experiment was to investigate the effects of SSS on theta production and creativity. Simultaneous sensory stimulation refers to the stimulation of several sense modalities simultaneously at an optimal level of stimulation. According to Leuba (1962):

> Optimal stimulation is a concept which refers to the totality of excitation of the sense organs, both those on the surface of, and those inside, the body. More precisely, it refers to a state of optimal innervation, arousal, or activation within the central nervous system. Still more precisely, it refers to a balance at an optimal level between input and outgo of innervation in the central nervous system. (p. 64)

Presumably this optimal level of activation is similar for most people (Sales, 1971) and is accompanied by pleasant feelings (Leuba, 1963). Several sense modalities were stimulated simultaneously since "it is the overall stimulation which is significant rather than the intensity of any one particular stimulus" (Leuba, 1955, p. 29). Simultaneous sensory stimulation occurred for 15 minutes since this has been found to be the optimal time for producing changes in creativity (Taylor, 1970; Taylor, Austin and Sutton, 1974).

Sensory Stimulation and Creativity

As mentioned previously, it has been demonstrated that SSS can be a significant factor in developing and facilitating creativity (Taylor, 1970, 1972; Taylor and Knapp, 1971). An increase was found in divergent thinking after exposure to SSS but no change was found in convergent thinking (a task that according to theory would be associated with beta production). Divergent thinking is viewed as playing a critical role in the creative process (Taylor, 1975).

Theta and Creativity

An important implication of theta production lies in the creative process. Green et al. (1970) drew attention to the existence of a relationship between alpha-and-theta brain wave activity and hypnagogic-like imagery and to the relationship between hypnagogic-like imagery and creativity. Koestler (1964), quoting Kretschmer, emphasized the predominance of reverie states reported in the literature concerning creative thinking:

> Such creative production of the artistic imagination tend to emerge from a psychic twilight, a state of lessened consciousness and diminished attentivity to external stimuli. Further, the condition is one of 'absentmindedness' with hypnoidal overconcentration on a single focus, providing an entirely passive experience, frequently of visual character, divorced from the categories of space and time, and reason and will. (p. 325)

There are literally hundreds of other anecdotes (Ghiselin, 1952; Green et al., 1970; Crutchfield, 1973) by people such as Poincare, Rollo May, Robert Louis Stevenson, A.E. Housman, Rudyard Kipling, to name a few, who did their creative thinking in states of abstraction, of sleep, and of dreaming.

Crutchfield (1973) refers to this part of the creative process as the incubation stage:

> The word "incubate" comes from a Latin word meaning "to lie down upon"; thus, when we speak of "sleeping on a problem", we are, in effect incubating. It is of interest also to note that in certain ancient Roman religious rites, incubation refers to lying down on a mat in order to have dreams in which one communicated with certain deities of the underworld. This original meaning has suggestive metaphorical implications for our thinking about incubation in the creative process. The incubation process would seem to be one in which the individual somehow gets in touch with something mysterious, beyond what is available in his usual conscious life. And, certainly, this is what a great many theorists have argued -- that the function of the incubation process is to permit some sort of unconscious ferment, some sort of unconscious ideational rearrangements which eventually lead to an insightful solution. (p. 64)

In his experiment involving the conscious control of theta rhythms, Green (1972) noted:

> Pictures or ideas would spring full blown into consciousness without the person being aware of their creation. The theta "reverie", as we began to call it, was definitely different from a day-dreaming state and much to our surprise we found that it seemed to correspond with descriptions given by geniuses of the past of the state of consciousness they experienced while being their most creative. (p. 156)

Green et al. (1975) also noted that the imagery often contained "answers from the unconscious" and have stated the purpose of their experimentation "to study the possibility of extending awareness by building a bridge between conscious and unconscious processes so that information might be obtained from normally unconscious processes" (p. 96).

Method

Subjects. Forty first year university students (volunteers who took part in the experiment for two academic credits) were divided into four groups as shown in Table A (see Appendix A). Each group had an equal number of males and females to control for sex differences. Only persons who were not predisposed to epileptic seizures as screened by the experimenter were used as subjects.

Apparatus. An Alphascan 600, Alpha/Theta Brainwave analyzer manufactured by the Bioscan Corporation was used for the theta monitoring and theta feedback sessions. An Alphascorer manufactured by the Bioscan Corporation converted the amount of theta produced per time interval into a percentage.

An EC2 Electrode Cream manufactured by Grass Instruments Company was applied to the scalp to enhance conductivity between the scalp and the electrodes. All electrodes were manufactured by the Bioscan Corporation and electrode placements were in accordance with their recommendations (Instructional Manual-Alphascan 600). One input electrode was placed on the forehead above the right eye, midway between the eyebrow and the hairline. The other input electrode was placed on the right occipital bone at the rear of the head. The ground electrode was placed on the temple region of the right side of the head.

Procedure. Each group received a pretest and a posttest of the Figural Tests of the Torrance Tests of Creative Thinking. The Figural Tests (Forms A and B) of the Torrance Tests of Creative Thinking were counterbalanced so that there were an equal number of pretest and posttest Form A's and Form B's for each level of stimulation and each sex member.

Preceding SSS and NS, all groups were told, "what you are about to experience may affect your thinking". The technique for producing SSS followed that of Taylor (1972) and took place in a darkened room involving several strobe and colored lights reflecting off walls and ceiling of silver paper for visual stimulation; an original composition of strings and percussion music stereophonically presented through headphones for auditory stimulation; comfortable reclining chairs which vibrate and heat for somasthetic and thermal stimulation; mentholated candies for gustatory stimulation; and incense for olfactory stimulation. Exposure to SSS was of a 15 minute duration.

Neutral stimulation took place in a small experimental room furnished with a table and chair and consisted of a 15 minute tape-recording of a lecture on thinking by a psychologist.

Immediately following SSS or NS the subjects were taken to another semi-darkened, experimental room where EEG equipment was used to monitor their brainwaves for 200 seconds. Before the monitoring session, all subjects were read instructions to the effect that their brainwaves were being monitored and were asked to remain still with their eyes closed (see Appendix B).

Immediately following the monitoring session, subjects in the theta feedback groups received instructions to the effect that they would receive a tone signal for a particular type of electrical activity from the brain and were asked to maintain this tone (see Appendix C). The feedback session lasted for 20 minutes, time in theta attained being recorded every 200 seconds.

Immediately following the monitoring session, subjects in the no feedback groups did not receive any further instructions and were monitored for an additional 20 minutes, time in theta attained being recorded every 200 seconds.

Immediately following the feedback-no feedback sessions (20 minutes) all subjects received a posttest of the Figural Test of the Torrance Tests of Creative Thinking.

Immediately following the posttest, all subjects were debriefed as to the nature and purpose of the experiment.

To control for experimenter bias, the study was run blind, that is, two experimenters were involved in this experiment: Experimenter A administered the SSS and NS treatments; Experimenter B administered the Torrance Tests of Creative Thinking and ran the monitoring and the theta feedback sessions without knowledge of the subjects' stimulation group. Two raters scored the Torrance Tests of Creative Thinking without knowledge of the subjects' identity or which group he/she was in. The inter-rater reliability coefficients were: Fluency, .97, Flexibility, .98, Originality, .95, and Elaboration, .90.

Analytic Procedures. Each subjects' amount of theta production per time interval was recorded as a percentage. To obtain the total amount of theta produced per monitoring trial (50 seconds) the score in percent-time would be divided by two. To obtain the total amount of theta produced per feedback trial (200 seconds) the score in percent-time would be multiplied by two. The amount of theta in percent-time was used for the data analyses. This would yield the same result as if actual time in theta was used.

The four raw scores derived from the Figural Tests of the Torrance Tests of Creative Thinking were used for the data analyses.

Results

Theta Production

Monitoring. A 2(Stimulation-Neutral Stimulation) x 2(Male-Female) x 4(Trials) analysis of variance yielded a significant main effect of stimulation $F(1,36)=10.28$, $p<.01$, (see Table 1). More theta was produced after stimulation ($\bar{X}=2.575$) than after neutral stimulation ($\bar{X}=.513$). The first hypothesis, therefore, was supported.

Feedback. A 2(Stimulation-Neutral Stimulation) x 2(Feedback-No feedback) x 2(Male-Female) x 6(Trials) analysis of variance yielded a significant main effect of stimulation $F(1,32)=7.35$, $p<.01$, (see Table 2). The mean amount of theta production after stimulation was 1.642, and the mean amount of theta production after neutral stimulation was .458. The main effect of feedback was significant (one-tailed) $F(1,32)=3.50$, $p<.05$. The group receiving feedback produced more theta ($\bar{X}=1.458$) than the group not reciving feedback ($\bar{X}=.642$). No interaction of feedback and stimulation was found. The second hypothesis, therefore, was not supported. The interaction effect of stimulation by sex was also found to be significant $F(1,32)=5.25$, $p<.05$, (see Fig.1).

To examine this interaction, a Newman-Keuls com-

Table 1

Complete Analysis of Variance on Percentage of Theta Production Over Four Fifty Second Monitoring Trials

Source	DF	SS	MS	F
SUBJ	39	786.94		
A (Stimulation)	1	170.16	170.16	10.28**
B (Sex)	1	.76	.76	.04
AB	1	20.31	20.31	1.22
Error AB	36	595.73	16.55	
C (Trials)	3	4.42	1.47	1.38
AC	3	3.07	1.02	.96
BC	3	8.07	2.69	2.53
ABC	3	2.22	.74	.69
Error ABC	108	114.98	1.06	

**$p < .01$.

Table 2

Complete Analysis of Variance on Percentage of Theta Production Over Six 200-Second Feedback Trials

Source	DF	SS	MS	F
SUBJ	39	597.40		
A (Stimulation)	1	84.02	84.02	7.35 **
B (Feedback)	1	40.02	40.02	3.50
AB	1	6.67	6.67	.58
C (Sex)	1	20.42	20.42	1.78
AC	1	60.00	60.00	5.25 *
BC	1	.27	.27	.02
ABC	1	20.42	20.42	1.78
Error ABC	32	365.60	11.42	
D (Trials)	5	4.90	.98	.99
AD	5	2.68	.54	.54
BD	5	.98	.20	.19
ABD	5	3.13	.63	.63
CD	5	10.48	2.10	2.12
ACD	5	3.70	.74	.75
BCD	5	2.73	.55	.55
ABCD	5	7.78	1.56	1.58
Error ABCD	160	157.60	.99	

*$p < .05$.

**$p < .01$.

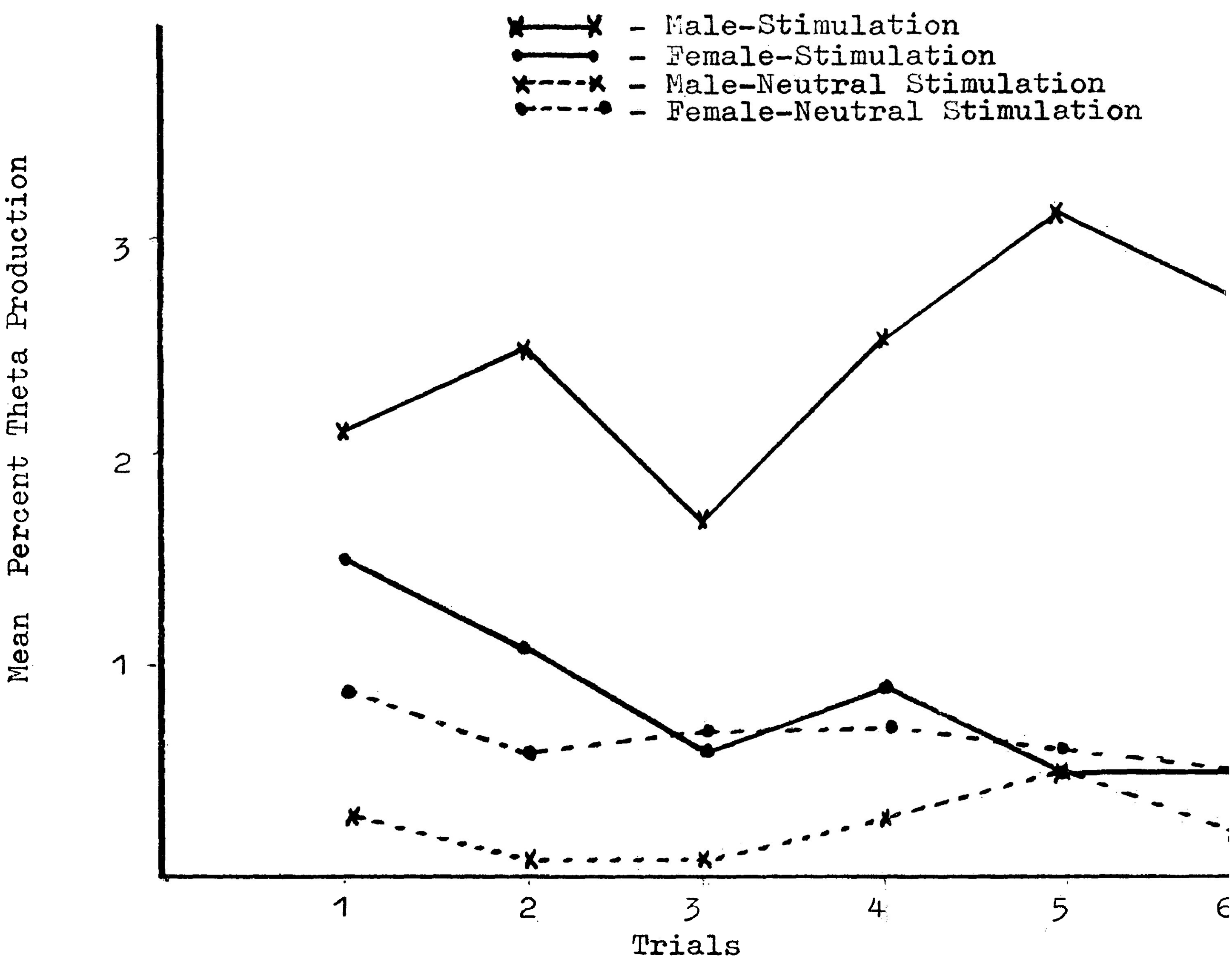

Figure 1. Mean percentage of theta production for the interaction of stimulation and sex over six feedback trials.

parison was calculated on the means. Males receiving stimulation showed a significantly greater amount of theta production than the other three groups (see Table 3). The other groups did not differ significantly among themselves.

Creativity

A 2(Stimulation-Neutral Stimulation) x 2(Feedback-No Feedback) x 2(Male-Female) x 2(Pretest-Posttest) analysis of variance was performed on each of the four creativity scores (see Table 4,5,6,7). No significant effects were found except an interaction effect of stimulation x sex x feedback on the originality measure $F(1,32)=8.556$, $p < .01$. The third hypothesis, therefore, was not supported.

Table 3

Newman-Keuls Comparison on Differences Between Pairs of Means for the Interaction Between Stimulation and Sex

Groups		NS-Male	NS-Female	SSS-Female	SSS-Male
	Means	.250	.667	.850	2.433
NS-Male	.250	--	.417	.600	2.183
NS-Female	.667		--	.183	1.766
SSS-Female	.850			--	1.583
SSS-Male	2.433				--

$q_{.95}(r,40)$	2.86	3.44	3.79	
$q_{.99}(r,40)$	3.82	4.37	4.70	
$\sqrt{\frac{MSerror}{n}} \times q_{.95}(r,40)$		1.25	1.50	1.65
$\sqrt{\frac{MSerror}{n}} \times q_{.99}(r,40)$		1.66	1.90	2.17

	NS-Male	NS-Female	SSS-Female	SSS-Male
NS-Male	--			**
NS-Female		--		*
SSS-Female			--	*
SSS-Male				--

*$p < .05$.
**$p < .01$.

Table 4

Complete Analysis of Variance on the Raw Scores for the Fluency Measure of Creativity

Source	DF	SS	MS	F
SUBJ	39	2365.19		
A (Stimulation)	1	.61	.61	.00
B (Feedback)	1	12.01	12.01	.17
AB	1	12.01	12.01	.17
C (Sex)	1	27.61	27.61	.40
AC	1	10.51	10.51	.15
BC	1	.01	.01	.00
ABC	1	132.61	132.61	1.95
Error ABC	32	2169.80	67.81	
D (Pretest-Posttest)	1	9.11	9.11	.36
AD	1	17.11	17.11	.68
BD	1	9.11	9.11	.36
ABD	1	12.01	12.01	.47
CD	1	13.61	13.61	.54
ACD	1	1.01	1.01	.04
BCD	1	15.31	15.31	.60
ABCD	1	12.01	12.01	.47
Error ABCD	32	804.20	25.13	

Table 5

Complete Analysis of Variance on the Raw Scores for the Flexibility Measure of Creativity

Source	DF	SS	MS	F
SUBJ	39	1533.00		
A (Stimulation)	1	2.45	2.45	.06
B (Feedback)	1	26.45	26.45	.63
AB	1	20.00	20.00	.48
C (Sex)	1	24.20	24.20	.58
AC	1	2.45	2.45	.06
BC	1	.45	.45	.01
ABC	1	125.00	125.00	3.00
Error ABC	32	1332.00	41.63	
D (Pretest-Posttest)	1	9.80	9.80	.68
AD	1	14.45	14.45	1.01
BD	1	11.25	11.25	.78
ABD	1	1.80	1.80	.13
CD	1	16.20	16.20	1.13
ACD	1	11.25	11.25	.78
BCD	1	1.25	1.25	.08
ABCD	1	16.20	16.20	1.13
Error ABCD	32	456.80	14.28	

Table 6

Complete Analysis of Variance on the Raw Scores for the Originality Measure of Creativity

Source	DF	SS	MS	F	
SUBJ	39	5614.95			
A (Stimulation)	1	64.80	64.80	.54	
B (Feedback)	1	145.80	145.80	1.22	
AB	1	18.05	18.05	.15	
C (Sex)	1	296.45	296.45	2.48	
AC	1	192.20	192.20	1.60	
BC	1	51.20	51.20	.43	
ABC	1	1022.45	1022.45	8.55	**
Error ABC	32	3824.00	119.50		
D (Pretest-Posttest)	1	20.00	20.00	.72	
AD	1	26.45	26.45	.95	
BD	1	.45	.45	.02	
ABD	1	.80	.80	.03	
CD	1	12.80	12.80	.46	
ACD	1	.45	.45	.02	
BCD	1	6.05	6.05	.22	
ABCD	1	7.20	7.20	.26	
Error ABCD	32	890.80	27.84		

**$p < .01$.

Table 7

Complete Analysis of Variance on the Raw Scores for the Elaboration Measure of Creativity

Source	DF	SS	MS	F
SUBJ	39	32010.80		
A (Stimulation)	1	845.00	845.00	.99
B (Feedback)	1	1080.45	1080.45	1.27
AB	1	26.45	26.45	.03
C (Sex)	1	259.20	259.20	.30
AC	1	441.80	441.80	.52
BC	1	130.05	130.05	.15
ABC	1	1980.05	1980.05	2.33
Error	32	27247.80	851.49	
D (Pretest-Posttest)	1	18.05	18.05	.18
AD	1	84.05	84.05	.85
BD	1	39.20	39.20	.39
ABD	1	231.20	231.20	2.35
CD	1	36.45	36.45	.37
ACD	1	2.45	2.45	.02
BCD	1	12.80	12.80	.13
ABCD	1	192.20	192.20	1.95
Error ABCD	32	3150.60	98.46	

Discussion

These data indicate that SSS increases theta production, thus supporting the first hypothesis. This effect was found immediately after SSS, in the monitoring session, and persisted into the feedback session. The results also indicate that males exposed to SSS maintained theta production longer than females exposed to SSS (see Fig. 1). In a study by Davidson and Schwartz (1976) it was found that the right hemisphere becomes more active in females than in males when attempting self-regulatory tasks and, since all EEG recordings were taken from the right hemisphere, it is possible that this sex difference in hemispheric activation contributed to the present finding.

The effect of feedback was significant for both the SSS and NS groups. The second hypothesis, therefore was not supported. Since the mean change scores for each group (total amount of theta production over six feedback trials minus total amount of theta production over four monitoring trials) was negative, it appears that feedback serves to allow <u>subjects</u> to more effectively maintain theta production rather than increase theta production.

The results did not support the hypothesis (3) that following SSS subjects will increase in creativity. This result is contradictory to previous studies (Taylor, 1970; Taylor, 1972; Taylor and Knapp, 1971) but, it is possible that the time lapse between exposure to SSS and the posttest on creativity was of sufficient duration (about 20 minutes) to cause a decaying of the effect. This explanation is partially supported by Tuokko's (1976) finding that SSS significantly increased originality scores on the Figural Tests of the Torrance Tests of Creative Thinking after a delay of approximately five minutes.

There is no apparent rational explanation for the additional finding of an interaction of stimulation, sex and feedback on the originality measure of creativity. Therefore, this result may be due to chance.

A theoretical construct which may explain the effects of increased stimulation is the concept of optimal stimulation. This is a homeostatic concept which suggests that, when overall stimulation is low, there is an increase in activity by the organism and, when overall stimualtion is high, there is a decrease in activity by the organism.

The present findings are in accordance with this theory. When exposed to increased stimulation for an optimal amount of time the subject's brain rhythms, which reflect the arousal of the individual, show an increase in slow theta rhythm production.

The present study can also be interpreted from the perspective of mediation theory. In this study the basic components of the mediation model (Vinacke, 1974) were examined, namely the input (SSS), the intrinsic activity or mediating process in terms of a psychophysiological event (theta brainwaves), and the output (creativity). Green, Green and Walters (1970) have hypothesized the relationship between theta production and creativity, the intrinsic event and the output, and are investigating this area. Taylor (1972) established the relationship between SSS and creativity, the input and the output. The present study established the relationship between SSS and theta production. The relationship between theta production and creativity is implied in the combined results of Taylor (1972), Tuokko (1976) and the present study.

From these results it appears that SSS can play an important role for the induction of a theta state. Theta, in the normal waking state, is very scarce and, hence, methods of induction have been devised such as pretraining in muscle relaxation (Budzynski and Stoyva, 1972) and mild sensory deprivation techniques (Gastaut, 1969).

It appears that SSS is more economical in terms of time as an induction technique.

There are a number of implications for the possible use of theta production. Since hypnagogic imagery occurs while in the low arousal state characterized by theta activity, it may be possible to focus on these internally generated stimuli to study the "inner man". For example, Budzynski (1972) suggested that an easily produced and controlled reverie state may increase production of primary process material and free association, delighting "therapists of analytic persuation" (p. 150).

It may also be possible to create a positive personality change through theta production. Foulkes and Vogel (1965) found that individuals with rigid, repressive, dogmatic personality traits reported less sleep-onset fantasy material. With a prolonged theta state subjects may become more aware of imagery, and, as mentioned before, have personally integrative experiences (Green, et al., 1975).

It has also been suggested that through theta production man may be able to explore altered states of consciousness without the use of drugs (Budzynski, 1972; Karlin and Andrews, 1972). Adept practitioners of various forms of meditation (Zen, Yoga, Sufism) show pronounced alterations in brain functioning (e.g., Kasamatsu and Hirai, 1969; Anand, Chhina and Singh, 1969; Green, 1972). Swami Rama has suggested the use of biofeedback control of brain rhythms to accelerate the training of young yogis up to the point where the machine would no longer be useful (Green, 1972).

Theta production has implications for both educational practices and therapies involving suggestion (Budzynski, 1972). Cobb, Evans, Gustafson, O'Connell, Orne and Shor (1965) found that subjects carried out hypnotic-like behavior while showing a stage 1 sleep pattern and it has been found that the EEG frequencies most predictive of hypnotic susceptibility were from the theta band (Galbraith, London, Leibovitz, Cooper and Hart, 1970). Also, Soviet scientists who have refined the techniques of sleep learning, have concluded that material is best assimilated during drowsy and light sleep stages (Rubin, 1970).

Since the onset of theta activity in the EEG is associated with a marked decrease in muscle tension (Sittenfeld, 1972), increasing theta production may also serve as a means to treat stress related disorders and may also be useful in alleviating sleep-onset insomnia.

Both Sittenfeld (1972) and Budzynski (1972) have found theta feedback valuable for self-induction of sleep for subjects who suffered from sleep-onset insomnia.

Certain limitations of this study should be noted. Given the design that was used, it was impossible to administer the creativity test immediately following SSS. The sex variable could have emphasized more strongly as an important factor because of the sex differences in creativity and in EEG activity during self-regulatory tasks. The range of the EEG spectrum examined could have been broader to include more than just theta activity. An Archimedes color wheel could have been placed in the SSS laboratory to better simulate the original laboratory used by Taylor (1972) at the Centre for Creative Leadership.

In order to improve this study, the above recommendations could be implemented. In addition, the following changes in design could be utilized: immediately after exposure to SSS one group could receive theta monitoring followed by a creativity measure while another group could receive a creativity measure followed by theta monitoring.

Conclusion

The results of the study indicate that SSS induces theta production. The effect of theta feedback was found to allow *subjects* to more effectively maintain theta production rather than to increase theta production. Also, an unanticipated difference in ability to maintain theta production between males and females was found, possibly due to the differences in hemispheric activation during self-regulatory tasks between males and females.

References

Anand, B.K., Chhina, G.S. and Singh, B. Some aspects of electroencephalographic studies in Yogis. In C.T. Tart (Ed.), Altered States of Consciousness. Garden City, New York: Doubleday and Company, Inc., 1969.

Bertini, M., Lewis, H.B. and Witkin, H.A. Some preliminary observations with an experimental procedure for the study of hypnagogic and related phenomena. In C.T. Tart (Ed.), Altered States of Consciousness. Garden City, New York: Doubleday and Company, Inc., 1969.

Brown, B. Recognition of aspects of consciousness through association with EEG alpha activity represented by a light signal. Psychophysiology, 1970, 6, 442-452.

Budzynski, T. Some applications of biofeedback produced twilight states. In N.E. Miller, T.X. Barber, L.V. DiCara, J. Kamiya, D. Shapiro and J. Stoyva (Eds.), Biofeedback and self-control, 1972; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1972.

Budzynski, T. Biofeedback procedures in the clinic. In N.E. Miller, et al. (Eds.), Biofeedback and self-control, 1973; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1973.

Budzynski, T. and Stoyva, J. Biofeedback techniques in behavior therapy. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1972; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1972.

Cobb, J., Evans, F., Gustafson, L., O'Connell, D., Orne, M., and Shor, R. Specific motor responses during sleep to sleep-administered meaningful suggestion: An exploratory investigation. Perceptual and Motor Skills, 1965, 20, 629-636.

Crutchfield, R.S. The creative process. In M. Bloomberg (Ed.), Creativity: Theory and Research. New Haven, Conn.: College and University Press Publishers, 1973.

Davidson, R. and Krippner, S. Biofeedback research: Data and implications. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1971; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1971.

Davidson, R. and Schwartz, G. Patterns of cerebral lateralization during cardiac biofeedback versus the self-regulation of emotion: Sex differences. Psychophysiology, 1976, 13(1), 62-68.

Duffy, E. Activation and Behavior. New York: John Wiley and Sons, Inc., 1962.

Forehand, R. and Baumeister, A.A. Effects of variations in auditory-visual stimulation on activity levels of severe mental retardates. American Journal of Mental Deficiency, 1970, 74, 470-474.

Foulkes, D. and Vogel, G. Mental activity at sleep onset. Journal of Abnormal Psychology, 1965, 70, 231-243.

Galbraith, G.C., London, P., Leibovitz, M.P., Cooper, L.M. and Hart, J.T. EEG and hypnotic susceptibility. Journal of Comparative Physiological Psychology, 1970, 72, 125-131.

Gastaut, H. Hypnosis and pre-sleep patterns. In Leon Chertok (Ed.), Psychophysiological Mechanisms of Hypnosis. New York: Springer-Verlag, 1969.

Ghiselin, B. (Ed.) The creative process: A symposium. Berkeley and Los Angeles: University of California Press, 1952.

Gottschalk, L.A., Haer, J.L. and Bates, D.E. Changes in social-alienation-personal disorganization and cognitive-intellectual impairment produced by sensory overload. Archives of General Psychiatry, 1972, 27, 451-457.

Green, E. Biofeedback for body-mind self-regulation: Healing and creativity. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1972; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1972.

Green, E., Green, A.M. and Walters, E.D. Voluntary control of internal states: Psychological and physiological. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1970; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1970.

Green, E., Green, A.M., Walters, E.D., Sargent, J.D. and Meyer, R.G. Autogenic feedback training. Psychotherapy and Psychosomatics, 1975, 25, 88-99.

Haer, J.L. Alterations in consciousness induced by sensory overload. Journal for the Study of Consciousness, 1970, 3, 161-169.

Haer, J.L. Field dependency in relation to altered states of consciousness produced by sensory overload. Perceptual and Motor Skills, 1971, 31, 192-194.

Hatayama, T. and Komatsu, H. Studies on sensory overload: 111. Results of polygraphic records: 11. Tohoku Psychologica Folia, 1971, 30, 5-9.

Kamiya, J. Conscious control of brain waves. Psychology Today, 1968, 1, 57-60.

Karlin, M. and Andrews, L. Biofeedback: Turning on the Power of Your Mind. Philadelphia: J.B. Lippincott Company, 1972.

Kasamatsu, A. and Hirai, T. An electroencephalographic study on Zen meditation (Zazen). In C.T. Tart (Ed.), Altered States of Consciousness. Garden City, New York: Doubleday and Company, Inc., 1969.

Kimmel, H.D., Pendergrass, V.E. and Kimmel, E.B. Modifying children's orienting responses instrumentally. Cond. Reflex., 1967, 2, 227.

Katamura, S., Hatayama, T. and Saito, S. Studies on sensory overload: 1V. General Survey. Tohoku Psychologica Folia, 1972, 31, 31-37.

Komatsu, H., Kawata, N. and Shimada, M. Studies on sensory overload: 1V. Part 1. Purposes, general methods and results of polygraphic recordings. Tohoku Psychologica Folia, 1972, 31, 11-17.

Koestler, A. The Act of Creation. New York: Macmillan, 1964.

Lawrence, J. Alpha Brain Waves. New York: Avon Books, 1972.

Leuba, C. Towards some integration of learning theories: The concept of optimal stimulation. Psychological Reports, 1955, 1, 27-33.

Leuba, C. Relation of stimulus intensities to learning and development. Psychological Reports, 1962, 11, 55-65.

Leuba, C. Behavioral implications of an optimal activation level in the nervous system. Paper presented at the meeting of the American Psychological Association, 1963.

Lindsley, D.B. Common factors in sensory deprivation, sensory distortion, and sensory overload. In P. Solomon (Ed.), Sensory Deprivation. Cambridge: Harvard University Press, 1961.

Luce, G.G. and Segal, J. Sleep. Gateshead on the Tyne: Northumberland Press Limited, 1967.

Ludwig, M. Self-regulation of the sensory environment. Archives of General Psychiatry, 1971, 25, 413-418.

Nowlis, D.P. and Kamiya, J. The control of electroencephalographic alpha rhythms through auditory feedback and the associated mental activity. Psychophysiology, 1970, 6, 476-484.

Pond, D.A. The development of normal rhythms. In D. Hill and G. Parr (Eds), Electroencephalography. London: Macdonald, 1963.

Raskin, M., Johnson, G. and Rondestvedt, J.W. Chronic anxiety treated by feedback-induced muscle relaxation: A pilot study. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1973; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1973.

Rubin, F. Learning and sleep. Nature, 1970, 226, 477.

Sales, S. Need for stimulation as a factor in social behavior. Journal of Personality and Social Psychology, 1971, 19, 124-134.

Sargent, J., Green, E.E. and Walters, E.D. Preliminary report on the use of Autogenic Feedback Training in the treatment of migraine and tension headaches. Psychosomatic Medicine, 1973, 35, 129-135.

Shapiro, D. and Schwartz, G.E. Biofeedback and essential hypertension and current findings and theoretical concerns. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1973; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1973.

Shapiro, D., Tursky, B. and Schwartz, G.E. Control of blood pressure in man by operant conditioning. Psychosomatic Medicine, 1970, 32, 417-423.

Sittenfeld, P. The control of EEG theta rhythm. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1972; An Aldine annual on the regulation of bodily processes and consciousness. Aldine Publishing Company, 1972, 506-507 (Abstract).

Sterman, M.B. and Friar, L. Suppression of seizures in epileptics following sensorimotor EEG feedback training. Electroencephalography and Clinical Neurophysiology, 1972, 33, 89-95.

Stoyva, J. Preface. In N.E. Miller et al. (Eds.), Biofeedback and self-control, 1971; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1971.

Taylor, I.A. Creative production in gifted young adults through simultaneous sensory stimulation. Gifted Child Quarterly, 1970, 14, 46-55.

Taylor, I.A. The effects of sensory stimulation on divergent and convergent thinking. Proceedings of the 20th International Congress on Psychology, 1972, 364.

Taylor, I.A. An emerging view of creative actions. In I.A. Taylor and J.W. Getzels (Eds.), Perspectives in Creativity. Chicago: Aldine Atherton, 1975.

Taylor, I.A. Simultaneous sensory stimulation and mental health. A paper presented at a meeting of the Canadian Psychological Association, 1976.

Taylor, I.A., Austin, G.D. and Sutton, D.F. A note on "Instant Creativity" at CPSI. Journal of Creative Behavior, 1974, 8, 208-210.

Taylor, I.A. and Knapp, M.W. Creative artistic productions of chronic schizophrenics through simultaneous sensory stimulation. Proceedings of the 79th Annual Convention of the American Psychological Association, 1971, 411-412.

Timmons, B., Salamy, J., Kamiya, J. and Girton, D. Abdominal-thoracic respiratory movements and levels of arousal. Psychonomic Science, 1972, 27, 173-175.

Torrance, E.P. Torrance Tests of Creative Thinking. Lexington, Mass.: Personnel Press/Ginn and Company (Xerox Education Company), 1966.

Torrance, E.P. Torrance Tests of Creative Thinking: Directions Manual and Scoring Guide (Figural Test Booklet A). Lexington, Mass.: Personnel Press/ Ginn and Company (Xerox Education Company), 1972.

Torrance, E.P. Torrance Tests of Creative Thinking: Directions Manual and Scoring Guide (Figural Test Booklet B). Lexington, Mass.: Personnel Press/ Ginn and Company (Xerox Education Company), 1974.

Tuokko, A.T. The effects of simultaneous sensory stimulation on creativity and field dependence. Master's Thesis, Lakehead University, 1976.

Vinacke, W.E. The Psychology of Thinking (2nd ed.). New York: McGraw-Hill Book Company, 1974.

Walter, W.G. The Living Brain. London: Gerald Duckworth and Co., 1953.

Weiss, T. and Engel, B.T. Operant conditioning of heart rate in patients with premature ventricular contractions. In N.E. Miller, et al. (Eds.), Biofeedback and self-control, 1971; An Aldine annual on the regulation of bodily processes and consciousness. Chicago: Aldine Publishing Company, 1971.

West, J.L. Hallucinations. In J.G. Howells (Ed.), Modern Perspectives in World Psychiatry. New York: Bruner/ Mazel Publishers, 1971.

Appendix A

Table A

Experimental Design for Administering Simultaneous Sensory Stimulation (SSS)-Neutral Stimulation (NS), Theta Feedback (F)-No Feedback (NF).

Group	Pre-test	Treatment	Monitor	Treatment	Post-test
1	X	SSS	X	F	X
2	X	SSS	X	NF	X
3	X	NS	X	F	X
4	X	NS	X	NF	X

Appendix B

Instructions to Subjects for Monitoring Sessions

A particular type (frequency) of electrical activity from your brain will be fed back to timers in the next room. Our electronic equipment is designed so that your brain waves turn on the timers, allowing us to monitor the electrical activity of your brain. During this time it is important that you do not move, as body movements may interfere with the monitoring of your brain waves. If you must move to remain comfortable, please notify the experimenter before doing so. Please keep your eyes closed throughout the session. Find a comfortable position, sit back and relax.

Appendix C
Instructions to Subjects for Feedback Sessions

A particular type (frequency) of electrical activity from your brain will be fed back to you by means of a tone signal. Our electronic equipment is designed so that your brain waves turn on a tone in these headphones, allowing you to hear the electrical activity of your brain. Try to keep the tone on as much as you can, by whatever means seems to work best. This is an individual matter only you can discover. During this time it is important that you do not move, as body movements may interfere with the monitoring of your brain waves. If you must move to remain comfortable, please notify the experimenter before doing so. Please keep your eyes closed throughout the session. Find a comfortable position, sit back and relax.