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TRANSCENDENTAL MEDITATION AND IMPROVED PERFORMANCE ON INTELLIGENCE-RELATED MEASURES: A LONGITUDINAL STUDY

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Summary—This two-year longitudinal study investigated the effect of participation in a special university curriculum, whose principal innovative feature is twice-daily practice of the Transcendental Meditation (TM) and TM-Sidhi program, on performance on Cattell's Culture Fair Intelligence Test (CFIT) and Hick's reaction time. These measures are known to be correlated with general intelligence. One hundred college men and women were the subjects—45 from Maharishi International University (MIU) and 55 from the University of Northern Iowa (UNI). The experimental group (MIU) improved significantly on the CFIT ($t = 2.79$, $P < 0.005$); choice reaction time ($t = 9.10$, $P < 0.0001$); SD of choice reaction time ($t = 11.39$, $P < 0.0001$), and simple reaction time ($t = 2.11$, $P < 0.025$) over two years compared to the control group, which showed no improvement. Possible confounds of subject's age, education level, level of interest in meditation, father's education level, and father's annual income were controlled for using analysis of covariance and stepwise regression. The results replicate the findings of previous longitudinal studies on intelligence test scores at MIU, and indicate that participation in the MIU curriculum results in improvements in measures related to general intelligence.

INTRODUCTION

Several investigators have noted the need for educational techniques which can develop fundamental cognitive abilities purportedly measured by IQ tests, such as the capacity for abstract thinking and information processing speed and efficiency (Caruso, Taylor & Detterman, 1982, Ch. 2; Feuerstein, 1979; Gardner, 1983; Lipman, Sharp & Oscanyan, 1980; Sternberg, 1986, pp. 21–22). Throughout this century, there have been attempts to develop these abilities, particularly the construct "*g*". Most of these attempts involved children of preschool or grammar school age, while a few involved high school age children (Feuerstein, 1979; Feuerstein, Rand, Hoffman & Miller, 1979), and elderly subjects (Baltes, Dittmann-Kohli & Kliegl, 1986; Baltes & Willis, 1982; Willis, 1987; Willis & Schaie, 1986; Willis, Blieszner & Baltes, 1981). The effects of these interventions have been summarized in several reviews (Brody, 1985; Caruso *et al.*, 1982; Jensen, 1969, 1989; Royce, Darlington & Murray, 1983; Spitz, 1986). Nearly all the interventions attempted to improve performance by training subjects in methods of learning or problem solving. In some cases, the material on which the subjects were trained was very similar to the material presented in psychometric tests (Baltes & Willis, 1982; Feuerstein 1979; Feuerstein *et al.*, 1979; Willis *et al.*, 1981; Willis & Schaie, 1986). As the reviewers point out, effects of these interventions on IQ scores have been on the whole disappointing or inconclusive.

On the other hand, two longitudinal studies reported improved performance on IQ tests among university students who practised the Transcendental Meditation (TM) and TM-Sidhi program, founded by Maharishi Mahesh Yogi (Aron, Orme-Johnson & Brubaker, 1981; Dillbeck, Assimakis, Raimondi, Orme-Johnson & Rowe, 1986), and another study reported significant longitudinal increases in IQ scores among high school students (Shecter, 1978). In the first university study, scores on Cattell's Culture Fair Intelligence Test (CFIT) rose 8 points over four years, and the second study reported a 9-point gain in CFIT scores over four years. In the high school study, scores on Raven's Advanced Progressive Matrices (APM) increased 9 IQ points after $3\frac{1}{2}$ months.

These findings may be attributed to the nature of the intervention involved. The TM and TM-Sidhi program differs from other interventions in that the practices involved are not designed to improve specific aspects of learning or problem-solving *per se*. Rather, they are described as techniques that promote general neurophysiological development, thereby unfolding general intellectual ability as well as other abilities (Maharishi Mahesh Yogi, 1963, 1969; Wallace, 1986).

A theoretical model of how TM could improve intelligence is provided in the well-established principle from developmental neurobiology that enriching experiences stimulate neural growth (Blakemore & Cooper, 1970; Edelman, 1987; Hubel & Weasle, 1979; Milgram, MacLeod & Petit, 1987; Pearson, Finkel & Edelman, 1987). An example of the principle is that animals raised in enriched environments develop greater brain weight than animals raised in deprived environments (e.g., Bennet, Diamond, Krech & Rosenzweig, 1964; Diamond, Ingham, Johnson, Bennet & Rosenzweig, 1976; Wallace, 1986, pp. 216–217). According to the ancient Vedic tradition of India as revived by Maharishi, which we will refer to as Vedic Psychology, the regular practice of Transcendental Meditation stimulates neurophysiological growth through a sequence of higher states of consciousness (Maharishi, 1969; Wallace, 1986). Alexander and his colleagues present evidence that these higher states constitute a systematic, stagewise extension of human development beyond upper bounds previously identified by western psychology (e.g., they are beyond Piaget's Formal Operations stage) (Alexander, Davies, Dixon, Dillbeck, Oetzel, Druker, Muehlman & Orme-Johnson, 1990). In this view, the mind is structured in hierarchical levels ranging from concrete to abstract, and utilization of these different levels is said to develop from concrete to abstract, e.g., from sensorimotor to abstract reasoning. Vedic Psychology holds that the most abstract level of the mind is transcendental consciousness, which is traditionally referred to as *samadhi* or *turya chetna* in Sanskrit (Maharishi, 1969). Transcendental consciousness (TC) is said to be "transcendental" in the sense that it is the silent level of pure wakefulness at the source of thought which is beyond even the most abstract thinking processes. Thought processes can be likened to the waves on an ocean and, in this simile, transcendental consciousness would be like the undisturbed, silent surface of the ocean once the waves have completely settled down.

The TM technique is described as a procedure that allows the attention to turn "inwards toward subtler states of thought until the mind transcends the subtlest state of thought and arrives at the source of thought," experienced as periods of content-free pure consciousness, or transcendental consciousness (Maharishi, 1969, p. 470). This is said to be the self-referral state of consciousness in which awareness is without any object outside of itself but is aware only of itself (Maharishi, 1963, 1969, 1972, 1986).

Physiological research in which subjects signal with a button press that an experience of TC has just occurred, shows respiratory suspension and increased EEG coherence among all cortical areas during periods of TC (Alexander, Cranson, Boyer & Orme-Johnson, 1987, review; Badawi, Wallace, Orme-Johnson & Rouzere, 1984; Farrow & Hebert, 1982; Gallois, 1984; Orme-Johnson & Haynes, 1981; Travis & Orme-Johnson, 1990; Wallace, 1970, 1986, review). A meta-analysis of 31 studies has shown that TM produces a state of physiological quiescence, with TM producing over twice the effect size of decreased respiration rate, decreased plasma lactate, and increased basal skin resistance compared to ordinary eyes-closed sitting (Dillbeck & Orme-Johnson, 1987). Other studies have shown increased blood flow to the brain (Jevning, Wilson, Smith & Morton, 1978), increased serotonin levels (Bujatti & Riederer, 1976; Walton, McCorkle, Hauser, MacClean, Wallace, Ieni & Meyerson, 1987) and decreased plasma cortisol (Bevan, 1980; Jevning, Wilson & Davidson, 1978; Jevning, Wilson & Smith, 1978; Jevning, Wilson, Vander Laan & Levine, 1975) during TM compared to resting controls. The EEG during TM shows an increase of alpha activity, suggesting a wakeful state in which the brain is at rest, but awake; not actively processing information but maintaining conscious awareness. Alpha EEG coherence also increases during TM, indicating that the EEG from various cortical areas have components that are very similar in frequency. Thus, increased global EEG coherence during TC suggests increased homogeneity of the brain's electrical field at that time. Experimental evidence indicates that during such periods of high EEG coherence the brain is maximally receptive to processing new information (e.g., Dillbeck & Araas-Vesely, 1986; Sheppard & Boyer, 1988). These physiological changes are reviewed at length in several books and articles (Alexander *et al.*, 1987; Dillbeck & Orme-Johnson, 1987; Wallace, 1970, 1986).

The TM-Sidhi program is described as an advanced aspect of the TM program whose purpose is to develop effective information processing while awareness remains established in the state of transcendental consciousness (Maharishi Mahesh Yogi, 1978, p. 51; Gelderloos & Van den Berg, 1989). This is said to further stimulate neurological growth, enabling clearer, more comprehensive mental performance in general (Maharishi Mahesh Yogi, 1963, 1969, 1972).

Physiological evidence that the experience of TC stimulates development can be found in longitudinal experiments, showing that practice of TM increases EEG coherence (Dillbeck & Bronson, 1981; Gaylord, Orme-Johnson & Travis, 1989; Gaylord, Orme-Johnson, Willbanks, Travis, Rainforth & Reynolds, 1989; Travis & Orme-Johnson, 1990). In addition the TM-Sidhi program further develops EEG coherence (Dillbeck, Orme-Johnson & Wallace, 1981; Orme-Johnson, Clements, Haynes & Badawi, 1977; Orme-Johnson & Haynes, 1981; Travis & Orme-Johnson, 1990). Correlational studies in meditators have shown that resting EEG coherence among frontal and central areas is positively correlated with higher levels of neurological efficiency, full scale WAIS IQ, fluency of verbal creativity, mathematics achievement, principled moral reasoning, and lower levels of neuroticism (Dillbeck *et al.*, 1981; Nidich, Ryncarz, Abrams, Orme-Johnson & Wallace, 1983; Orme-Johnson *et al.*, 1977; Orme-Johnson & Haynes, 1981; Orme-Johnson, Wallace, Dillbeck, Alexander & Ball, in press). Thus the longitudinal increases in these EEG parameters would suggest cognitive development.

The TM and TM-Sidhi program also produces several other physiological changes that would suggest increased cognitive abilities. Argenine vasopressin has been associated with improved learning and memory, and argenine vasopressin is elevated during TM (Jevning, Wells, Wilson & Guich, 1987). Shorter latencies and higher amplitudes of auditory evoked potentials have been associated with more efficient information processing in the brain, and TM and TM-Sidhi participants have been found to have shorter latency and larger amplitude evoked potentials than controls (Cranson, Goddard, Orme-Johnson & Schuster, 1990; Goddard, 1989; Kobal, Wandhofer & Plattig, 1975; Wandhofer, Kobal & Plattig, 1976). The TM-Sidhi program also increases paired H-reflex recovery rate, an indicator of adaptability of the nervous system and a correlate of academic achievement, EEG coherence, and concept learning (Dillbeck *et al.*, 1981; Wallace, Mills, Orme-Johnson, Dillbeck & Jacobe, 1983; Wallace, Orme-Johnson, Mills & Dillbeck, 1984).

Although the three previous longitudinal studies on the TM and TM-Sidhi program showing improvements in IQ can be explained by theory and are supported by past research, most previous TM studies on IQ lacked a control group. Only Shecter's short-term study of a high school sample included a control group, and therefore it may be argued that observed increases in IQ scores in university students simply reflect a rise in scores among the general university population or test–retest learning effects, rather than a change unique to practitioners of the TM and TM-Sidhi program. The present study addressed this problem by using non-meditating university students as a control group. In addition to studying IQ, it used a psychophysiological measure of speed and efficiency of information processing—choice reaction time.

Previous research indicates a relationship between choice reaction time, intraindividual SD of choice reaction time, and "*g*", considered by some investigators to be a measure of general intelligence (Barrett, Eysenck & Lucking, 1986; Eysenck, 1982, 1986, 1987, 1988; Frearson & Eysenck, 1986; Jensen, 1982a, b, 1985a, b, 1987; Jensen & Munro, 1979; Smith and Stanley, 1988; Vernon, 1983, 1987). It may be hypothesized that if the practice of the TM and TM-Sidhi program increases IQ, it should also improve performance on these psychophysiological measures. Holt, Caruso and Riley (1978) found a significant decrease in visual choice reaction time in TM meditators compared to non-meditating controls, while Appelle and Oswald (1974) found a decrease in variability of simple RT. However, to date no single study has investigated the effect of the TM and TM-Sidhi program on both IQ scores and RT measures.

In addition to investigating the effect of the TM and TM-Sidhi program on psychophysiological development as measured by choice reaction time and IQ scores, the investigators wished to verify whether reduction of mental "noise", achieved through the TM and TM-Sidhi program, would result in reduction of intraindividual SD of choice reaction time, said by some investigators to be a measure of "noise" in the information processing system (Jensen, 1987, pp. 134–136; Eysenck, 1987, p. 38).

We also examined correlations between IQ scores and reaction time measures, as in other correlational studies of these variables.

METHOD

Subjects

Subjects were freshman students at two universities in Iowa. The experimental group consisted of 45 students (25 males and 20 females) at Maharishi International University (MIU). The mean age was 25.2 years, SD = 6.74. The comparison group consisted of 55 students (22 males and 33 females) at the University of Northern Iowa.* Mean age was 19 years, SD = 1.8. Both groups had enrolled in introductory psychology courses, UNI students as an elective and MIU students as a part of the required first year curriculum.

Variables

The independent variable is participation or non-participation in the educational program at MIU, whose main innovative feature is the twice daily practice of the Transcendental Meditation (TM) and TM-Sidhi program. Otherwise, the curriculum at MIU is comparable to that of other universities. Eighty-four percent of the MIU subjects had been practising the TM program prior to their enrollment at MIU and 58% had been practising the TM-Sidhi program as well. However, once at MIU their practice was done as a group, since it was now a part of the educational program. The remaining 42% of the MIU subjects learned the TM-Sidhi program during their first six months at MIU.

The dependent variables were Cattell's Culture Fair Intelligence Test (CFIT), simple and choice reaction time (Hick's 1-light and 8-light configurations), and intra-individual SD of Hick's 8-light RT.

Design

The design of comparing the experimental group and the control group was an untreated non-equivalent control group design with pretest and post test. The experimental group (MIU freshman students) received pretest on the above measures, then received two years of education at MIU, including the twice-daily practice of the TM and TM-Sidhi program.

The control group received pretest at the same time as the experimental group, and post-test after the first two years of a standard university education.

Since random assignment to experimental and control groups was not possible, data were gathered from both groups on variables known to be related to performance on IQ tests. These data included subject's age and education level, father's education level, and father's annual income. These variables were introduced as covariates in the analysis, which appears in the results section.

To control for the possible influence of self-selection in the experimental group, data were gathered from both groups regarding subject's level of interest in meditation. Since interest in meditation was uniformly high for the experimental group but was varied within the control group, the effect of level of interest on post test scores for all variables was analyzed for the control group. The results are presented in the results section.

Apparatus

The apparatus for measuring reaction time (RT) was modeled after an apparatus used by Jensen (1987). It consisted of a panel, 13 in × 17 in, painted black and tilted at a 30 degree angle. At the lower center of the panel was a red pushbutton, $\frac{1}{2}$ in. in diameter, called the "home" button. Eight red pushbuttons, all equidistant (6 in.) from the "home" button, were arranged in a semicircle

*A fairly high attrition rate for the first two years of enrollment is characteristic of MIU and UNI, these two universities being typical of American universities in this regard. Hence, 97 subjects were pretested at MIU and 125 at UNI. As expected, by post test these numbers had decreased to 45 at MIU and 55 at UNI. Analyses were performed to address the question of whether attrition could have been responsible for any observed differences at post test, and these are reported at the end of the *Results* section.

around it. A $\frac{1}{4}$ in green light was mounted half an inch above each of the buttons in the semicircle. The console was connected to an Apple IIe computer through the game port, and a computer clock (Mountain Hardware Apple model) was used to measure RT.

Procedure

For the Hick's reaction time tests, subjects were instructed to place the index finger of the preferred hand on the home button. This caused an auditory warning signal (a high pitched "beep") to sound, followed (after a random interval of from 1 to 4 sec) by one of the eight green lights going on. The subject was previously instructed to turn off the light as quickly as possible by pressing the red button directly below the light. In the one-light condition, on each trial the same light went on (right of top center). In the eight-light condition, the particular light that went on in each trial was random and hence unpredictable. RT was the time the subject took to remove his or her finger from the home button after the green light went on. Movement time (MT) was independently measured as the time taken to move the finger from the home button to the button under the green light. On each trial RT and MT were registered in milliseconds by the computer clock with an accuracy of within 1 msec and recorded by the computer. Upon completion of the 20-trial set for each subject, the mean RT and the standard deviation of RT for 20 trials (a measure of intraindividual variability) were computed and recorded by the computer.

Each subject was given 5 practice trials in the one-light condition (the same light came on for every trial), and subsequently 20 trials in that condition. Then each subject received 5 practice trials in the eight-light condition (any one of the eight lights came on randomly) and 20 trials in that condition.

Cattell's CFIT was administered according to the standard procedure given in the test instructions.

RESULTS

As mentioned in the design section, potential confounds related to performance on IQ measures were tested as covariates. These additional covariates were: level of interest in meditation, subject's age, subject's education level, father's education level, and father's annual income. The covariates on which the two groups differed significantly at pretest were age ($\bar{X}_E = 25.34$, SD = 6.73; $\bar{X}_C = 19$, SD = 1.8), education, and level of interest in meditation. The higher mean age of the experimental group would not predict better performance on the CFIT and RT measures than the control group, since scores on all of them, if anything, are negatively correlated with age (Birren & Renner, 1977; Botwinick, 1977; Horn & Cattell, 1967; Welford, 1980), although the negative correlation is generally not seen before age 40.

To test for an effect of interest in meditation on post test scores of the control group on the five dependent variables, separate stepwise regressions were performed with pretest scores and interest in meditation as the covariates. The alpha level was $P < 0.05$ to enter and $P > 0.05$ to remove. The effect of interest in meditation was not significant in any of the regressions; hence, for the control group it was concluded that level of interest in meditation had no effect on post-test scores on any of the measures.

Next, stepwise regressions were performed for experimental and control groups combined, to determine whether potential covariates were significantly related to post test performance on the four dependent variables—Cattell's CFIT, Hick's 1-light RT, Hick's 8-light RT, and intraindividual SD of Hick's 8-light RT—with $P < 0.05$ to enter and $P > 0.05$ to remove a covariate. Subject's age, subject's education level, and father's education level were included as covariates, in addition to pretest scores for the appropriate dependent variable. Since data on father's annual income was available for only about half the subjects, a separate stepwise regression was performed for each dependent variable using pretest scores and father's annual income as covariates, in order to maximize the number of available cases for analyses using the other covariates.

For each variable, pretest score entered the stepwise regression first. Father's education was also kept in the regression for CFIT post-test scores at $P < 0.05$; age and father's education were kept in the regression for scores on Hick's 8-light RT at $P < 0.05$. Hence, age and father's education

were entered as covariates into the test of the assumption of homogeneity of slopes in preparation for one-way MANCOVA on post-test scores for CFIT, 1-light RT, 8-light RT, and SD of 8-light RT. Neither subject's education nor father's annual income were kept in any of the regressions at $P < 0.05$, and therefore these two covariates were dropped from further analysis.

For the group of dependent variables, in the first test of the assumption of homogeneity of slopes there was a statistically significant ($P < 0.0001$) interaction between CFIT pretest scores and the grouping variable, and also between age and the grouping variable ($P = 0.037$). These results indicated: (a) The univariate test of the assumption of homogeneity of slopes for CFIT scores should be performed to determine whether an interaction between CFIT pretest scores and the grouping variable would appear in that analysis as well. This would indicate one-way ANCOVA could not be performed for this variable. (b) The effect of age would have to be viewed with caution if age were found to be statistically significant as a covariate in the MANCOVA.

MANCOVA was performed with age and father's education as covariates. Neither age nor father's education were statistically significant as covariates. Hence it was clear that neither age nor father's education exerted a significant effect on post test scores of the four dependent measures; therefore both covariates were dropped from further analysis.

The MANCOVA for post test scores on the dependent variables was performed again without the two control covariates, including only pretest scores as covariates. Wilks' lambda for the difference between groups was 0.298 and the F statistic was 31.20 ($P < 0.000005$, $df = 4,53$). Hence, the null hypothesis of no effect of the grouping variable on post test scores, covarying for pretest, for the four dependent variables was rejected. The effect was in the direction of improvement on the four dependent measures in the experimental group.

The next step, before proceeding to univariate ANCOVAS, was to test the assumption of homogeneity of slopes for each of the four dependent variables separately. The assumption of homogeneity of slopes was supported for all dependent variables, including CFIT scores.

Separate 1-way ANCOVA's were then performed for post test scores on the CFIT, 1-light RT, 8-light RT and SD of 8-light RT, with pretest scores as the covariate in each case. Table 1 presents the results. The F-test value was converted to a t-test value in order to obtain one-tailed P-values for testing the directional hypothesis of an improvement in the experimental group relative to controls (see Rosenthal & Rosnow, 1984, p. 244).

Results for CFIT scores, Hick's 8-light RT, Hick's 8-light intraindividual SD, and Hick's 1-light RT were all statistically significant in the predicted direction. Since the assumption of homogeneity of slopes was supported for CFIT scores in the individual one-way ANCOVA, it was concluded that the initial performance of MANCOVA was justified even though CFIT pretest scores interacted with the grouping variable when initially testing the assumption of homogeneity of slopes for the four dependent variables.

Figure 1 presents pretest–post test change in scores on the CFIT for the experimental and control groups.

Table 1. One-way analyses of covariance for effect of group on CFIT: Hick's 1- and 8-light RT, and SD of 8-light RT

Variable or covariance	Group	$\bar{x}$ pre	SD pre	$\bar{x}$ post	SD post	Adj. $\bar{x}$ post	df	F	t	P
Cattell's CFIT	Exper.	26.82	5.19	29.03	5.26	29.17				
	Control	27.32	3.84	27.02	4.34	26.91	88		2.79	<0.005
Pretest covariate	Exper.									
	Control						88	50.24		<0.0001
Hick's 1-light RT	Exper.	311.46	46.52	278.70	47.23	275.62				
	Control	300.61	57.71	290.39	36.86	292.98	78		2.11	<0.025
Pretest covariate	Exper.									
	Control						78	26.05		<0.0001
Hick's 8-light RT	Exper.	350.57	47.11	320.14	30.53	335.05				
	Control	467.27	107.11	492.75	76.03	480.21	77		9.10	<0.0001
Pretest covariate	Exper.									
	Control						77	8.65		<0.004
SD of 8-light RT	Exper.	106.63	136.51	45.25	19.90	45.30				
	Control	263.22	167.45	289.73	112.13	289.67	66		11.4	<0.0001
Pretest covariate	Exper.									
	Control						66	0.000		0.992

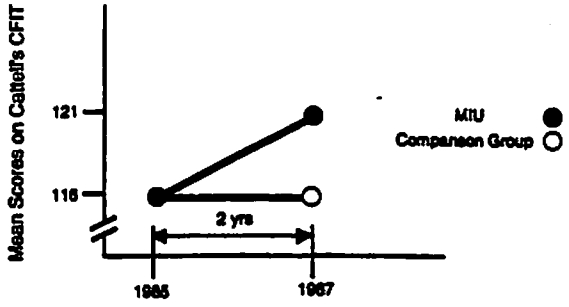

Fig. 1. Change in scores on Cattell's Culture Fair IQ (CFIT) test over two years for experimental group (MIU) and comparison group.

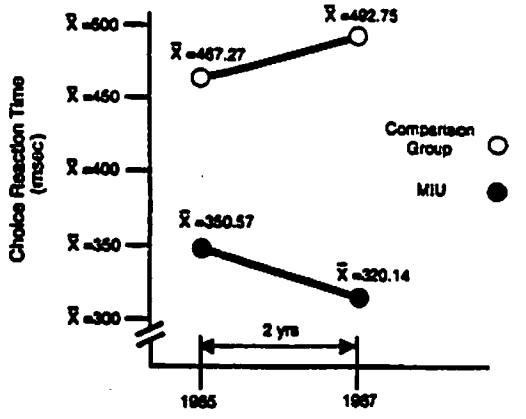

Fig. 2. Change in Hick's 8-light reaction time over two years for experimental group (MIU) and comparison group.

Since pretest means for the CFIT were identical for the experimental and control groups, regression to the mean was discounted as an alternative hypothesis to explain the results.

Figure 2 shows pretest–post test change in scores on Hick's 8-light RT.

The pretest mean for the experimental group ($\bar{X} = 350.57$ msec) is consistent with findings of other researchers (Jensen, 1985a, p. 163; Frearson & Eysenck, 1986). A statistically significant negative correlation was found between Hick's 8-light RT and CFIT post test scores ($r = -0.290$, $P < 0.005$).

Figure 3 presents pretest–post test change in SD of 8-light RT. The Pearson correlation between SD of RT and CFIT post test scores was -0.0256 ($P < 0.01$).

The possibility of attrition affecting post test scores is now considered. Because of the size of the attrition rate, MANOVA was performed with group and pre-post completion/non-completion as the independent variables. Dependent variables were pretest scores for CFIT, 1-light RT, 8-light RT, and SD of 8-light RT. The main effect of completion/non-completion was not statistically significant (Wilks' Lambda = 0.976, $F = 1.143$, $P = 0.338$, $df = 4,185$), nor was the interaction between group and pre-post completion/non-completion (Wilks' Lambda = 0.954, $F = 2.239$, $P = 0.067$, $df = 4,185$). Hence, the null hypothesis of no differences between subjects who completed or did not complete the tests was accepted.

The group effect was statistically significant (Wilks' Lambda = 0.632, $F = 26.949$, $P < 0.00001$, $df = 4,185$), indicating that the experimental group (MIU) performed better at pretest than the control group. This result argues against regression to the mean as the cause of significant change in MIU scores from pretest to post test.

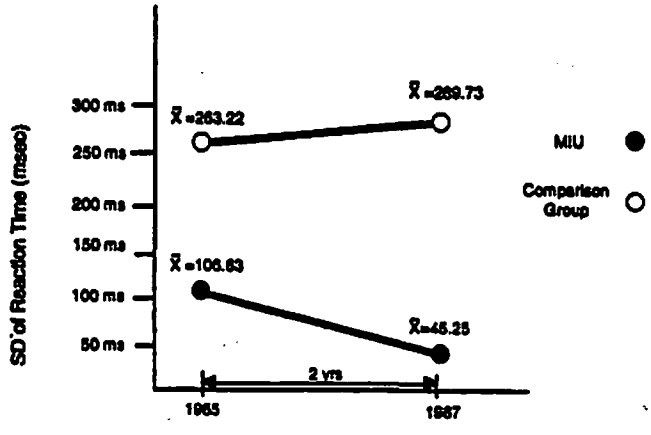

Fig. 3. Change in SD of Hick's 8-light reaction time over two years for experimental group (MIU) and comparison group.

DISCUSSION

The results support the hypothesis that regular practice of the TM and TM-Sidhi program in a university setting results in significant improvements in cognitive performance, as measured by an IQ test and choice reaction time measures. One statistical concern may be that the subjects were not randomly assigned to the experimental and control groups. In practice, true random assignment experiments are rare in the social sciences because of their difficulty and expense. Analysis of covariance is generally considered an appropriate method of analysis where random assignment is not possible in an untreated control group design with pretest and post-test (Reichardt, 1979, pp. 149–150). Using analysis of covariance, the present experiment found that interest in meditation, subject's age, subject's education level, father's education level, father's annual income and pretest differences between groups could not account for the results. The groups were initially the same on IQ, yet the experimental group increased significantly over the two year treatment period while the controls remained virtually unchanged. The experimental group was initially superior on the reaction time measures, yet it improved even more at post testing, the opposite of what would be expected from a regression to the mean effect. It is difficult to imagine how initially shorter choice reaction times and lower standard deviations might predispose subjects to improve even more on these highly objective measures.

With regard to random assignment, it is interesting to note that a meta-analysis of 146 independent outcomes found that the effect size of the TM technique on reducing trait anxiety was over twice that of other meditation techniques, and that this conclusion held when only studies using random assignment and low attrition were considered. In fact, random assignment studies showed an even greater effect size for the TM technique and a greater contrast between the TM techniques and the other techniques than did studies of lesser experimental design (Eppley, Abrams & Shear, 1989). This demonstrates the reliability of the effects of the TM technique, at least on trait anxiety, and the present strong findings on intelligence, together with the previous research that it replicates, are a strong indication that TM's effects on cognitive ability are also reliable.

It may be claimed that improvements in the dependent measures were caused by the teaching methods and academic information given students at MIU rather than their practice of the TM and TM-Sidhi program. The academic knowledge taught at MIU does include elements which relate the student's experience of the development of consciousness through the TM and TM-Sidhi program to the laws of nature studied by traditional academic disciplines. However, a study by Shecter (1978), indicated that improvements in IQ test scores resulted from the direct experience of the TM technique rather than intellectual study of the development of consciousness. In Shecter's study, high school students were randomly assigned to three groups: one group learned Transcendental Meditation; a second group took a 14-week Science of Creative Intelligence course in which they studied development of consciousness but did not learn the TM technique; and a third group took both courses. A fourth matched group took neither course. Those practising the Transcendental Meditation technique (either with or without the Science of Creative Intelligence course) showed significantly greater improvement on IQ test scores than those who did not practice the TM technique (either with or without the Science of Creative Intelligence course).

In explaining performance on speeded tasks, several investigators (Eysenck, 1986; Gardner, 1983; Jensen, 1982a; Sternberg, 1985; Vernon, 1985) have described the information processing system as a system of limited-capacity processors or components. They have proposed that individual differences in choice reaction time and performance on IQ tests are associated with differences either in operation of neural substrates, or in capacity of components of the information processing system such as short-term and long-term memory. It may be that the psychophysiological development fostered by experiences of more abstract states of the thinking process during TM includes expansion of the capacity of the information processing system, resulting in improved performance on such tasks.

Long-term practitioners of the TM and TM-Sidhi program appear to be capable of spontaneously maintaining broadened awareness while simultaneously focusing their attention on a task (Dillbeck, 1982; Dillbeck *et al.*, 1986; Pelletier, 1974; Travis, 1988; Travis & Orme-Johnson, 1990). This ability to maintain a broad, comprehensive style of awareness while simultaneously focusing on the parts of a problem may account for observed improvements in performance on choice

reaction time and tests of figural reasoning, since both tests emphasize the ability to perceive and analyze relations of parts with one another and with a larger whole, and to respond accordingly. For example, on the Hick's 8-light RT task, some subjects spontaneously volunteered that they were able to perceive the whole field of eight lights simultaneously and respond quickly and accurately when the target light came on, rather than serially scanning the lights and trying to anticipate the correct choice.

Figure 3 shows a decrease in intraindividual SD of Hick's 8-light RT, considered by some to be an index of "noise" in the information processing system, and the RT-related variable most strongly correlated with IQ measures (Eysenck, 1987; Jensen, 1987). As mentioned earlier, although SD scores for the MIU group were initially lower by 150 msec, their scores improved significantly, descreasing by 58.29 msec, while scores increased insignificantly (37.5 msec) for the control group.

This reduction of noise in the information processing system is explained by the theory associated with the TM and TM-Sidhi program, mentioned in the Introduction. According to the Vedic principles underlying TM, the technique directly reduces noise in the information processing system by allowing the individual to experience progressively quieter, more abstract states of thought until his or her awareness becomes silent or noise-free in the state of transcendental consciousness (Maharishi Mahesh Yogi, 1963, pp. 48–49, 1969, pp. 278, 282, 1972). Regular practice of the TM and TM-Sidhi program is predicted to stimulate development of the nervous system such that it can maintain this noise-free state along with information processing in the waking state (Maharishi Mahesh Yogi, pp. 103, 114–116, 1969, pp. 135–137, 150–153, 1972). The present finding of reduced RT variability operationalizes and supports this prediction. In addition, the observed changes in IQ scores and reaction time measures can also be interpreted as reflecting an improved signal-to-noise ratio in the system, as can the reduction in trait anxiety found in other research (Eppley *et al.*, 1989).

Previous research (Barrett *et al.*, 1986; Eysenck 1986, 1988; Frearson & Eysenck, 1986; Jensen, 1979, 1982a, 1982b, 1985a, 1985b, 1987; Smith & Stanley, 1988; Vernon, 1983, 1987) indicates the measures used here are correlated with the theoretical construct "*g*", or general intelligence. The findings indicate that "*g*" can be developed, as measured by IQ tests and reaction time tests. The study does not contradict the theory that "*g*" is largely genetically determined (Bouchard & McGue, 1981; Bouchard & Segal, 1985; Jensen, 1969, 1985b; McGue & Bouchard, 1988; McGue, Bouchard, Lykken & Feuer, 1984; Plomin, 1988). Rather it suggests that the TM and TM-Sidhi program facilitates the expression of inherent potential by providing experiences of subtle levels of thought which stimulate central nervous system development and hence unfold general cognitive ability (e.g., Alexander *et al.*, 1990; Wallace, 1986). This theoretical perspective has now been supported and cross-validated by studies using IQ tests (Aron *et al.*, 1981; Dillbeck *et al.*, 1986; Shecter, 1978; present study), cognitive tests of information processing (Dillbeck, 1982), choice reaction time (Holt *et al.*, 1978; present study), EEG coherence (Dillbeck & Araas-Vesely, 1986; Dillbeck & Bronson, 1981), and evoked potential measures (Cranson *et al.*, 1990; Goddard, 1989; Kobal *et al.*, 1975; Wandhofer *et al.*, 1976).

These studies indicate that the TM and TM-Sidhi program is a promising educational technology for enhancing the learner's ability to learn. Clearly, if intelligence could be increased, it would complement all other approaches to improving education. Large-scale evaluative research programs in various educational settings are needed in order to assess the impact this technology could have if implemented throughout society.

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