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Meditation and flexibility of visual perception and verbal problem solving

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This study investigates the effects of the regular practice of the Transcendental Meditation (TM) technique on habitual patterns of visual perception and verbal problem solving. The study's predictions were expressed in the context of Norman's model, which suggests that meditation reduces conceptually driven processes. It was specifically hypothesized that the TM technique involves a reduction of habitual patterns of perceptual and conceptual activation, resulting in (1) more effective application of schemata to new information and (2) less distracting mental activity during performance. This was predicted to result in improved task performance on task conditions in which either (1) habitual patterns of performance hinder or do not aid performance or (2) habitual patterns aid performance. Subjects began the TM technique, relaxed, or added nothing to their daily schedule for 2-week periods. In addition to generalized effects of the interventions, the immediate effects of the TM technique, relaxation, and reading were compared on a letter perception task. The general hypothesis was supported for tasks of tachistoscopic identification of card and letter-sequence stimuli, but not for the verbal problem solving task of anagram solution.

This study investigates the effect of the regular practice of the Transcendental Meditation (TM) technique on perception and cognitive manipulation of habitual and unfamiliar stimuli. The TM technique is described as a systematic means of reducing the level of mental activity while maintaining alertness; regular experience of this process, in alternation with ordinary activity, is said to result in both broader comprehension and greater ability to focus attention (Maharishi Mahesh Yogi, 1969). If so, the technique should affect perceptual processes. Previous perceptual research on the TM technique found an increase in the field-independent mode of perception in beginning participants in the TM program, after 3 months, on the embedded figures test, the rod-and-frame test, and the autokinetic perception test (Pelletier, 1974).

Within the existing cognitive literature, one framework for understanding how the TM technique could affect the information processing system is a model of meditation suggested by Norman (Lindsay & Norman, 1977). This suggestion is that the reduction of mental activation reported by subjects involves the bypassing of the usual "conceptually driven" analysis of incoming data, although that information is still processed by the "data-driven" sensory apparatus. This model accurately describes the fact that TM participants notice and show evoked potentials to sensory events occurring during meditation (Wandhoefer, Kobal, & Plattig, 1976). In addition, a reduction of conceptual processing during the TM technique seems indicated by EEG research in terms of the absence of alpha blocking to a click stimulus (Banquet, 1973), as well as the absence of contingent negative variation (Paty, Vincent, & Faure, 1977).

A reduction of conceptually driven processing during the TM technique implies reduced activation of perceptual and memory schemata by sensory data. I suggest that this reduction of habitual patterns of activation would subsequently allow the more effective and flexible application of schemata to new information. This could be measured as more effective performance on task conditions in which habitual patterns do not aid performance or even hinder it, that is, in which the stimulus is unfamiliar or unexpected. In addition, reduced physiological and cognitive excitation may subsequently result in less distracting mental activity during task performance. This could be measured as improved performance also on perceptual and cognitive tasks in which habitual patterns usually aid performance (i.e., for familiar stimuli).

The purpose of this experiment was to assess whether improvement in these two types of task conditions is evidenced as a result of the TM technique. Three tasks generating established experimental effects were chosen; in each, habitual patterns of perceptual or cognitive

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activity have been found to facilitate or to hinder performance.

Letter Identification

The first task was initially employed by Miller, Bruner, and Postman (1954) and deals with the effects of habitual linguistic patterns on the perception of letter sequences. In a full-report tachistoscopic identification task of nonsense words constructed at various degrees of linguistic approximation to English, the number of letters reported correctly was directly proportional to the degree of approximation to English. Thus, habitual linguistic patterns can be said to help the identification of word-like sequences, relative to random sequences.

Card Identification

A second experimental task, employed by Bruner and Postman (1949), measured tachistoscopic identification thresholds to conventional and incongruous playing cards. Performance was poorer on the incongruous cards, which had the usual suit color reversed (e.g., a red six of spades). Subsequent studies indicate that this effect is due to the formation of incorrect perceptual hypotheses from initial incorrect interpretation of cues of color and shape (i.e., an incorrect perceptual schema) (Bruner & Potter, 1964; Chastain & Burnham, 1975).

Anagrams

The third task focuses on the effects of habitual linguistic patterns on cognitive processes subsequent to perception, namely, the verbal problem solving paradigm of an anagram task. If English-like letter clusters are more easily perceived, one would hypothesize that such a linguistic unit could be less easily broken for rearrangement in an anagram solution task. This hypothesis was supported and replicated under task conditions in which subjects had to break up anagrams composed of letter units either of high or low frequency to form words composed of infrequently used letter units (Dominowski & Duncan, 1964; Mayzner & Tresselt, 1959). Given the experimental conditions of these studies, habitual linguistic patterns can be said to hinder the solution of highly word-like anagrams relative to random anagrams.

The general theoretical prediction that an effect of the TM technique is subsequent performance in which the individual is less restricted by habitual patterns of perceptual and cognitive activity and yet able to function more effectively within them leads to three specific hypotheses. The first is that an immediate effect of a single experience of the TM technique, in contrast to a normal rested state, is an increase in effective functioning in tasks in which habitual perceptual patterns either aid or do not aid performance. The second hypothesis is that with the repeated experience of reduced mental activity during the TM technique, these effects will generalize and be measurable outside the period immediately following meditation. That is, the same results predicted in the first hypothesis should be evident following the 2 weeks of practice of the TM technique, in contrast to the effects of daily rest periods. Finally, it is hypothesized that after 2 weeks, improved performance will also be evident on the anagram task on task conditions in which habitual linguistic patterns either aid or do not aid performance.

METHOD

Subjects

Sixty-nine subjects who were students or spouses of students at Purdue University were recruited from two sources. A sample who expressed interest in the TM program by attending an introductory lecture on the topic provided 43 volunteers (33 males, 10 females) who would later learn the TM technique. Each of these subjects was paid $20 for participating. An additional group of 26 university students (21 males, 5 females) served as no-treatment controls. These subjects volunteered from an introductory psychology subject pool and received experimental credit to fulfill a course requirement. The average subject age was 21.3 years.

Due to experimental error, the data of four of the control subjects were disregarded for the card perception task and the data of one subject from each of the other groups into which the TM-technique sample was assigned (see "Procedure") were omitted from analysis of the letter perception task. The data of one subject in each of the last two experimental groups were also disregarded on the card perception task due to visual difficulties in color-form identification, as measured by control stimuli described below. The collection of data from one subject from the TM-technique sample on the card perception task was omitted due to prior familiarity with the task. Additionally, 7 other subjects from an initial total of 50 volunteers from the TM program lecture sample completed only the initial testing before deciding not to continue with the experiment. These seven subjects took part in no experimental treatments and were included in neither the data analysis nor the subject description above.

Apparatus

A Gerbrands two-field tachistoscope (Model T-2B) was employed for the tachistoscopic tasks. It had a display field 3 in. square with an illumination of 6.3 fc (67.8 lx).

Letter identification. The letter sequences tachistoscopically presented for identification were typed in uppercase on plain white index cards. Each letter sequence subtended a vertical visual angle of .33 deg and a horizontal visual angle of 1.80 deg. On each trial of the task, each subject was presented a series of 20 eight-letter sequences for 100 msec each. Half were zero-order (random) and half were four-order (highly word-like) approximations to English, with the order of these sequences randomly arranged and received in the same order by all subjects. Subjects reported the letters they had seen from each stimulus on an answer sheet that had eight blanks for each sequence. They were instructed not to guess randomly to fill in positions.

For each trial of 10 random and 10 word-like sequences, two scores were recorded: the percentage of total letters correctly identified regardless of exact placement (hits) and the percentage of intrusion errors (false alarms). In a manner similar to Murdock (1968), this method of analysis views the report task as a yes-no procedure in which the subject supplies the alternatives. That is, in reporting the letter B, the subject has implicitly asked, "Did B occur?" and has responded positively.

If B did not actually occur, the response is judged a false positive; if it did occur, the response is a hit. The subject's knowledge that there are 8 letters/sequence provides a constraint on the number of such questions the subject is assumed to ask.

The percentages of hits and false alarms were combined into a sensitivity measure according to two different models, those given by high-threshold theory and the theory of signal detection. These two theories represent two poles in the possible modeling of the processes of the observer: from the single response state of high-threshold theory to the continuum of response states of the theory of signal detection (Coombs, Dawes, & Tversky, 1970, p. 193). The purpose of this was to assess whether effects found from the techniques would be independent of the model assumed. The sensitivity measure dictated by high-threshold theory is $p(D|s) = [p(Y|s) - p(Y|n)]/[1 - p(Y|n)]$, where $p(Y|s)$ and $p(Y|n)$ are the probability of a hit and a false alarm, respectively. The measure of sensitivity from signal detection theory (d') was calculated from hit and false alarm percentages by a table provided by Hochhaus (1972). The response bias measure (β) was also calculated from this table. In order for the parameters to be calculable from this table, .99 or .01 was substituted for a hit rate or false alarm rate of 1.0 or 0, respectively, whenever such a value occurred.

Card identification. The conventional and color-reversed playing cards were made by a printing company on cardboard with the glossy surface of normal playing cards. Each card subtended a vertical visual angle of 7.77 deg and a horizontal visual angle of 6.50 deg. In addition, black or red geometric figures of the same size as the card shapes were printed on the same material and served as a control for possible perceptual difficulties. Each of these figures, a circle, square, or triangle, subtended both vertical and horizontal visual angles of .98 deg.

On each testing, the subject was presented six cards, three conventional and three incongruous. The mean numerical value of the cards was equal both between trials and between the two card conditions within each trial, to control for differences in the amount of information presented. No cards were repeated. Each stimulus was presented three times at each successively longer tachistoscopic duration (incremented exactly as in Bruner & Postman, 1949) until the subject was able to identify the card correctly on two consecutive exposures. The criterion score was the log exposure time at which identification occurred, from the raw score range of 10-1,000 msec.

Anagrams. The anagrams used in the anagram task were typed on index cards for individual presentation. On each trial, the subject received 10 five-letter anagrams, 5 of which were composed of low-frequency bigrams (random) and 5 of which had high bigram frequency (word-like). The mean bigram frequency of the high and low groups was 4,335 and 414, respectively, according to the "total" bigram frequency counts of Underwood and Schultz (1960, pp. 332-335). The number of letter moves required for solution was equalized between trials and between conditions of each trial. The solution words were in a low-frequency use group (5-15 times/million by Thorndike-Lorge norms) and also had low bigram frequency (mean bigram frequency total of 2,077 by Underwood & Schultz norms).

Solution times for the anagrams were recorded by stopwatch to the nearest 1 sec, with a maximum time of 150 sec allowed for each. Because one of the low bigram frequency anagrams in each trial was found during testing to have two solutions, those three anagrams were not included in the analysis; the mean solution times of each subject for high and low bigram frequency anagrams were used as the criterion scores for each trial. Multiple-solution anagrams would alter the criterion of selecting anagrams with solution words composed of infrequently used letter units.

Procedure

Subjects who volunteered to participate in the experiment from among those interested in the TM technique were randomly assigned to two groups: one group that waited 2 weeks before beginning the TM technique (Group N-TM) and one that practiced passive relaxation twice daily for 2 weeks before beginning the TM technique (Group R-TM). The third group (Group N-N), which was not randomly assigned, consisted of subjects from the psychology course who neither relaxed nor practiced the TM technique; this group served as a control for practice effects due to repeated measures of the tasks.

Subjects beginning the TM technique received standard TM instruction by the Students International Meditation Society in Lafayette, Indiana. This course, after two lectures describing the technique, consisted of four 1-h meetings on consecutive days, one individually and three in a group of those who learned. The technique is said to involve learning both a meaningless sound ("mantra") chosen for the individual as a focus of attention and also a technique for using the sound without effort; the technique is also described as not employing concentration, suggestion, or conceptual contemplation. Subjects practiced the technique for 15-20 min twice daily, in the early morning and late afternoon. The relaxation procedure practiced during the first 2 weeks by Group R-TM was one in which subjects sat for the same amount of time that they would later practice the TM technique and passively relaxed without a focus of attention, allowing their thoughts to flow freely, with eyes closed.

All three groups were tested on the letter identification and anagram tasks before and after this first 2-week period and again after 2 weeks of twice-daily practice of the TM technique. The card identification task was given only twice, before and after the 4-week experimental period, because a large practice effect that washes out the initial conventional-incongruous card difference is found if exposure to incongruous cards is too frequent (Bruner & Postman, 1949).

In addition to these task administrations, in order to measure the immediate or state effects of a single experience of the TM technique or relaxation, the letter identification measure was readministered on one testing session for each group immediately after a 20-min period of the TM technique for Group N-TM, relaxation for Group R-TM, or reading for Group N-N. For Group R-TM, this took place on the second testing session before beginning the TM technique, and for the other two groups, it took place on the final testing session. Group N-TM subjects were tested before and after their usual meditation (early morning or late afternoon) in order to most accurately assess the immediate effects of the TM technique.

Subjects were tested individually by experimenters who did not know the experimental condition of the subjects, except for 5.8% of the trials, in which testing had to be done by the author.

Table 1 charts the experimental design. As is evident from this table, the fact that not all subjects received the same letter identification stimuli at the same time offers potential for confounding. There is also potential for confounding immediate and longer term (2-week) effects. That is, because Group N-TM subjects were tested right before and after their usual meditation, if immediate effects of meditation occur, and if they fade with time, then neither the measurement before nor the measurement after the meditation period may be as characteristic of subjects' usual performance as the last testing of Group R-TM, which was between usual meditations. That is, for Group N-TM, performance on the first of these last two testings might be lower than otherwise and performance on the second might be higher than otherwise; this is a problem in using that group to assess longer term effects.

However, the analysis problems for the letter identification task are not intractable. The 2-week effects of relaxation can be assessed from Session 1 to Session 2 (Letters 2 in Table 1) for all three groups. In order to make maximum use of the data in analysis of the 2-week effects of the TM technique, changes from Letters 2 to Letters 4 (see Table 1) for all three groups can be assessed; this compares no intervention with testing

Table 1
Design Chart

Testing Session				
1	Intervention	2	Intervention	3
		Group N-TM (n = 20)		
Letters 1	None	Letters 2	TM Technique	Letters 3 TM Technique Letters 4
Cards 1				Cards 2
Anagrams 1		Anagrams 2		Anagrams 3
		Group R-TM (n = 23)		
Letters 1	Relax	Letters 2 Relax Letters 3	TM Technique	Letters 4
Cards 1				Cards 2
Anagrams 1		Anagrams 2		Anagrams 3
		Group N-N (n = 26)		
Letters 1	None	Letters 2	None	Letters 3 Read Letters 4
Cards 1				Cards 2
Anagrams 1		Anagrams 2		Anagrams 3

Note–Testing sessions were separated by 2 weeks.

after reading (Group N-N), 2 weeks of the TM technique with testing between daily meditations (Group R-TM), and 2 weeks of TM technique with testing immediately after meditation (Group N-TM). The immediate effects of the TM technique, in comparison with reading, are measured from Letters 3 to Letters 4 (see Table 1) for Groups N-TM and N-N. Only in the case of the immediate effects of relaxation is it impossible to avoid confounding of time and session differences. The change in performance of Group R-TM from Letters 2 to Letters 3 (see Table 1), the relaxation period, might be compared with the same stimuli for Group N-N, which are separated by 2 weeks; a comparison might also be made with the reading interval for Group N-N (Letters 3 to Letters 4), which is a later time period with different stimuli. In this case of the immediate effects of relaxation, both comparisons will be made; if the results are comparable, inferences might be warranted.

RESULTS AND DISCUSSION

In general, the results supported the hypotheses for the perceptual tasks, but not for the anagram task. Results are presented and discussed in relation to each hypothesis.

However, before proceeding to the hypotheses, preliminary analyses were performed to assess the comparability of the three groups on each measure because Group N-N was not randomly assigned from the same pool as the other two groups. These analyses indicated that the three groups did not differ on the measures d′ or β for either condition of the letter identification task, nor did they differ for either condition for the card identification task or anagram task. They did differ, however, on the measure p(D|s) for both random and word-like conditions of the letter identification task. The one-way ANOVAs for the letter identification task were as follows: $F(2,63) = .07$ (MSe = .013, $p > .05$) and $F(2,63) = 2.36$ (MSe = 4.15×10^{-3}, $p > .05$) for the measure d′ for random and word-like letter sequences, respectively; $F(2,63) = 1.40$ (MSe = 11.70, $p > .05$) and $F(2,63) = .02$ (MSe = 21.00, $p > .05$) for β for random and word-like sequences, respectively; $F(2,63) = 4.23$ (MSe = .015, $p < .05$, $\omega^2 = .09$) and $F(2,63) = 3.20$ (MSe = .039, $p < .05$, $\omega^2 = .06$) for p(D|s) for random and word-like sequences, respectively. Post hoc comparisons of the significant effects for p(D|s) using Duncan's test ($p < .05$) showed that performance among both R-TM and N-TM subjects was higher on Session 1 than performance of N-N subjects for random letter sequences; for word-like sequences, only the difference between N-N and N-TM was significant, with the latter group performing better. The initial group means are graphed in Figure 1 with the longitudinal effects of the interventions.

For the log identification score on the card task, the ANOVA results were not significant [$F(2,58) = .82$, MSe = .042, $p > .05$, and $F(2,58) = .39$, MSe = .49, $p > .05$, for conventional and incongruous playing cards, respectively]. The results for the square root transformed solution time score on the anagram task were similarly nonsignificant [$F(2,64) = .75$, MSe = 7.02, $p > .05$, and $F(2,64) = .64$, MSe = 12.24, $p > .05$, respectively, for anagrams of low and high bigram frequency].

The three groups thus appear generally comparable on the initial testing, except for the measure p(D|s) for the letter identification task. To control for initial differences and for greater power of analysis in the pre-post design, analysis of covariance will be primarily used in subsequent data analysis (Huck & McLean, 1975). In addition, if comparable results are found for the two sensitivity measures on the letter identification

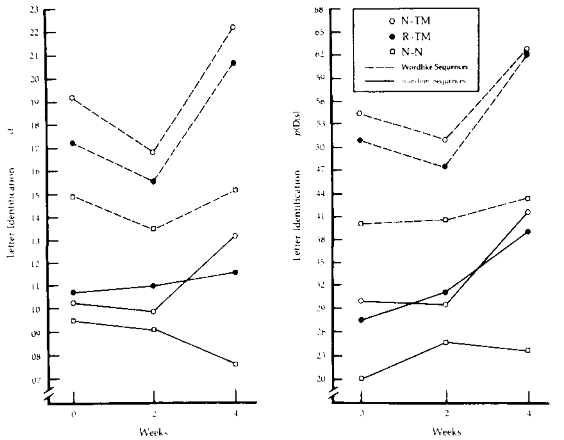

Figure 1. Mean letter identification scores for random and word-like letter sequences before and after an initial 2 weeks of practice of relaxation (Group R-TM) or no intervention (Groups N-TM and N-N), followed by 2 weeks of practice of the TM technique (Groups N-TM and R-TM) or no intervention (Group N-N). Group N-TM was tested the final time immediately after its usual meditation, and Group R-TM was tested between usual twice-daily meditations. Standard errors were the same as each category for Figure 2, except for random sequences d′ for controls, for which the SEM was .03 for the first testing.

task, d′ and p(D|s), then it would also not be likely that the effects would be due to the initial difference on p(D|s), since there was no significant initial difference for d′.

Immediate Perceptual Effects

The first hypothesis predicts immediate improvements in performance on the letter identification task among TM-technique subjects in contrast to those relaxing or reading, for both random and word-like letter sequences. The data were generally consistent with this hypothesis. In contrast to reading, subjects tested before and after the TM technique improved performance for both types of letter sequence; however, there was also evidence of an improvement for relaxing subjects for word-like sequences only.

To assess the effects of the TM technique and reading, the data were analyzed by one-way ANCOVAs comparing Groups N-TM and N-N at Letters 4 covarying for Letters 3 (see Table 1). The group difference was significant in the predicted direction for both random and word-like letter sequences, as measured by both d′ and p(D|s) [for random sequences, $F(1,42) = 9.42$, $MSe = 1.21 \times 10^{-3}$, $p < .01$, $\omega^2 = .15$, and $F(1,42) = 20.52$, $MSe = 7.38 \times 10^{-3}$, $p < .001$, $\omega^2 = .30$, for d′ and p(D|s), respectively; for word-like sequences, $F(1,42) = 15.48$, $MSe = 2.00 \times 10^{-3}$, $p < .001$, $\omega^2 = .24$, and $F(1,42) = 18.77$, $MSe = 7.72 \times 10^{-3}$, $p < .001$, $\omega^2 = .28$, for d′ and p(D|s), respectively]. As indicated by Figure 2, the subjects practicing the TM technique increased in performance relative to the subjects reading. There were no changes in the measure of response bias β for either random or word-like letter sequences [$F(1,42) = .81$, $MSe = 4.33$, $p > .05$, and $F(1,42) = 2.25$, $MSe = 19.26$, $p > .05$, respectively].

In assessing the effects of relaxation for Group R-TM, the change in performance from Letters 2 to 3 was compared with the change from both Letters 2 to 3 and Letters 3 to 4 for Group N-N (see end of Procedure section above). The results, again using one-way ANCOVAs, were generally consistent with both analysis procedures. There were no significant differences between groups for random letter sequences [$F(1,45) = 1.55$, $MSe = 9.22 \times 10^{-4}$, $p > .05$, and $F(1,45) = .99$, $MSe = 7.41 \times 10^{-3}$, $p > .05$, for d′ and p(D|s), respectively, for the comparison at Letters 2 and 3 for Group N-N; for the comparison using Letters 3 and 4 for Group N-N, $F(1,35) = 1.40$, $MSe = 1.15 \times 10^{-3}$, $p > .05$, and $F(1,45) = .78$, $MSe = 7.63 \times 10^{-3}$, $p > .05$, for d′ and p(D|s), respectively]. However, for word-like letter sequences, there was a significant increase in performance among subjects who relaxed as measured by three of the four comparisons: d′ and p(D|s) using Letters 3-4 for Group N-N and only p(D|s) when using Letters 2-3 for Group N-N. These analyses were as follows: $F(1,45) = .78$ ($MSe = 1.70 \times 10^{-3}$, $p > .05$) and $F(1,45) = 5.71$ ($MSe = 8.87 \times 10^{-3}$, $p < .025$, $\omega^2 = .09$) for d′ and p(D|s), respectively, for Letters 2-3 of Group N-N; for Letters 3-4 of Group N-N, $F(1,45) = 17.61$ ($MSe = 1.67 \times 10^{-3}$, $p < .001$, $\omega^2 = .25$) and $F(1,45) = 28.51$ ($MSe = 8.35 \times 10^{-3}$, $p < .001$, $\omega^2 =$

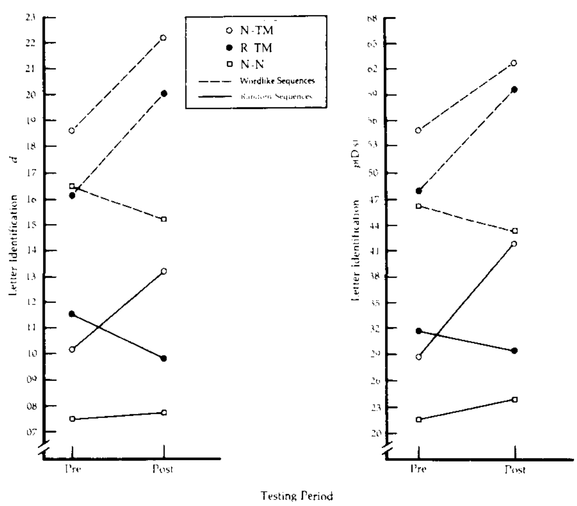

Figure 2. Mean letter identification scores for random and word-like letter sequences before and after a single period of the TM technique (Group N-TM), relaxation (Group R-TM), or reading (Group N-N). Groups N-TM and N-N were measured at Letters 3 and 4; Group R-TM was measured at Letters 2 and 3. The standard error was .01 for each mean for d′, .02-.03 for each mean of random sequences for p(D|s), and .04 for each word-like sequence mean for p(D|s).

.36) for d′ and p(D|s), respectively. Figure 2 charts the changes in performance for subjects who relaxed.

Finally, there were no significant differences between the relaxation and reading subjects for changes in the response-bias parameter, β, for either random or word-like letter sequences. The results of these one-way ANCOVAs were as follows: $F(1,45) = 1.05$ ($MSe = 4.28$, $p > .05$) and $F(1,45) = .87$ ($MSe = 12.72$, $p > .05$) for random and word-like sequences, respectively, for the comparison with Letters 2-3 of Group N-N and $F(2,45) = .05$ ($MSe = 4.10$, $p > .05$) and $F(1,45) = .94$ ($MSe = 11.64$, $p > .05$) for random and word-like sequences, respectively, for the comparison with Letters 3-4 of Group N-N.

In summary, as predicted by the first hypothesis, there was an immediate improvement in performance on the letter identification task for both random and word-like letter sequences after practicing the sequences. This change was not attributable to changes in response bias. An interesting unpredicted finding is that relaxation appeared to have an immediate effect similar to the TM technique in enhancing identification only for the word-like letter sequences. This was evident for three of the four comparisons for word-like sequences. Recall that the random and word-like letter sequences were randomly presented. This effect of relaxation in improving perception only when linguistic patterns aid perception (word-like sequences) but not when their absence does not aid performance (random sequences) implies that simple relaxation is a rest that reinforces habitual perceptual patterns but does not result in a generalized improvement in performance independent of these past patterns of activation. In contrast, the TM technique resulted in the immediate effect of improvement in both conditions.

Although this finding for relaxation was unpredicted, the results are consistent with the theoretical assumption initially put forward that the decrease of cognitive excitation produced by the TM technique is one in which conceptually driven information processing is reduced, and after which the individual functions more effectively and yet is less bound by habitual perceptual schemata. It was on this theoretical assumption that the longer term changes over a 2-week period were predicted for the TM technique, but not for relaxation or no practice.

Longitudinal Perceptual Effects

The second hypothesis predicts an improvement over a 2-week interval for TM-technique periods as opposed to relaxation and control periods in both conditions of the two perceptual tasks.

Letter identification. As predicted by the second hypothesis, the results of the letter identification task indicated an increase in performance for both random and word-like letter sequences for the subjects practicing the TM technique for a 2-week period, in contrast to subjects relaxing or practicing no procedure. These results were stronger for the word-like letter sequences than for the random letter sequences. There were no changes in the response-bias measure.

In order to assess the effects of relaxation during the first 2-week period, orthogonal a priori comparisons in a one-way ANCOVA design were run comparing the three groups on the second measurement of the letter identification task (Letters 2) covarying for the first measurement of the task. The two comparisons were between the adjusted groups means of the relaxation group (R-TM) and the other two groups and between the two other groups separately (N-TM and N-N). The comparisons between Group R-TM and Groups N-TM and N-N were not significant for either d′ or p(D|s) for either random or word-like letter sequences [$F(1,62) = 1.64$, $MSe = 1.62 \times 10^{-3}$, $p > .05$, and $F(1,62) = 1.13$, $MSe = 6.19 \times 10^{-3}$, $p > .05$, for d′ and p(D|s), respectively, for random letter sequences; $F(1,62) = .07$, $MSe = 1.56 \times 10^{-3}$, $p > .05$, and $F(1,62) = .19$, $MSe = .01$, $p > .05$, for d′ and p(D|s), respectively, for word-like letter sequences]. The comparisons between Groups N-TM and N-N were also not significant for any of the variables [$F(1,62) = .38$, $MSe = 1.62 \times 10^{-3}$, $p > .05$, and $F(1,62) = .53$, $MSe = 6.19 \times 10^{-3}$, $p > .05$, for d′ and p(D|s), respectively, for random letter sequences; $F(1,62) = 1.22$, $MSe = 1.56 \times 10^{-3}$, $p > .05$, and $F(1,62) = .007$, $MSe = .01$, $p > .05$, for d′ and p(D|s), respectively, for word-like sequences].

Finally, there were also no significant group differences in the response-bias measure, β, for either of the two group comparisons for either random or word-like letter sequences [for the comparison of Group R-TM with Groups N-TM and N-N, $F(1,62) = .03$, $MSe = 6.59$, $p > .05$, and $F(1,62) = .13$, $MSe = 12.88$, $p > .05$, for random and word-like letter sequences, respectively; for the comparison of Group N-TM with Group N-N, $F(1,62) = .08$, $MSe = 6.59$, $p > .05$, and $F(1,62) = 1.04$, $MSe = 12.88$, $p > .05$, for random and word-like letter sequences, respectively].

The effects of the TM technique during the second 2-week period were also analyzed by orthogonal a priori comparisons on adjusted group means of a one-way ANCOVA. In these analyses, as described at the end of the Procedure section, the final testing of the letters task (Letters 4) was compared, covarying for the measure of the letters task given at the end of the first 2-week period (Letters 2); in this way, 2 weeks of the TM technique with testing between meditations (Group R-TM) was compared with 2 weeks of the TM technique with testing immediately after meditation (Group N-TM), and 2 weeks of no practice with testing immediately after reading (Group N-N). One orthogonal comparison was between the two TM-technique groups (R-TM and N-TM) and Group N-N; the other comparison was between Groups R-TM and N-TM.

The comparison between the two TM-technique groups and Group N-N was significant in the predicted direction for both random and word-like letter sequences [$F(1,62) = 15.87$, $MSe = 1.31 \times 10^{-3}$, $p < .001$, $\omega^2 = .18$, and $F(1,62) = 22.74$, $MSe = 9.09 \times 10^{-3}$, $p < .001$, $\omega^2 = .25$, for d′ and p(D|s), respectively, for random letter sequences; $F(1,62) = 10.02$, $MSe = 2.77 \times 10^{-3}$, $p < .01$, $\omega^2 = .12$, and $F(1,62) = 14.63$, $MSe = .02$, $p < .001$, $\omega^2 = .17$, for d′ and p(D|s), respectively, for word-like sequences]. As indicated by Figure 1, these effects represent an increase in performance associated with the TM technique.

The comparison between the two TM-technique groups (R-TM and N-TM) was significant only for one of the variables, the measure d′ for random letter sequences. This effect was an increase in performance in Group N-TM, tested immediately after meditation, in comparison with Group R-TM. This is illustrated in Figure 1. The analyses for these comparisons are as follows: $F(1,62) = 4.51$ ($MSe = 1.31 \times 10^{-3}$, $p < .05$, $\omega^2 = .05$) and $F(1,62) = 1.75$ ($MSe = 9.09 \times 10^{-3}$, $p > .05$, for d′ and p(D|s), respectively, for random letter sequences, and $F(1,62) = .15$, ($MSe = 2.77 \times 10^{-3}$, $p > .05$) and $F(1,62) = .20$, $MSe = .02$, $p > .05$) for d′ and p(D|s), respectively, for word-like sequences. The significant increase in Group N-TM (tested immediately after meditation) relative to Group R-TM raises the question of whether the comparison of Groups R-TM and N-TM relative to Group N-N was significant only due to the influence of Group N-TM. However, a post hoc comparison using Duncan's procedure indicated that the adjusted group mean of Group R-TM was significantly higher than that of Group N-N ($p < .05$), although on Letters 4 the increase in Group R-TM was not great in absolute terms.

There were no significant differences in the response-bias measure, β, for either of the two comparisons for either random or word-like letter sequences [for the comparison of Group N-N with Groups R-TM and N-TM, $F(1,62) = 2.26$, $MSe = 4.95$, $p > .05$, and $F(1,62) = .41$, $MSe = 17.31$, $p > .05$, for random and word-like letter sequences, respectively; for the comparison of Groups R-TM and N-TM, $F(1,62) = 3.78$, $MSe = 4.95$, $p > .05$, and $F(1,62) = .55$, $MSe = 17.31$, $p > .05$, for random and word-like sequences, respectively].

In general, the longitudinal results on the letter identification task were consistent with the prediction that repeated reduction of conceptually driven mental activity, hypothesized to occur during the TM technique, results in improved performance over time on perceptual task conditions both when habitual patterns do not aid performance and when they do. That is, there was an increase in performance on both word-like and random letter sequences among subjects who regularly practiced the TM technique in contrast to relaxation or no treatment.

Card identification. Consistent with the second hypothesis, there was an improvement in performance among both groups of subjects who learned the TM technique, in contrast to control subjects, for the identification of incongruous cards; a parallel result was not found for normal cards. This task was analyzed by a one-way ANCOVA with orthogonal a priori comparisons of adjusted means. One comparison was between the two groups who learned the TM technique (N-TM and R-TM) and the control group (N-N); the other was between Groups N-TM and R-TM. In these analyses, the second testing was the dependent measure and the first testing was the covariate. The variable used for each of these sessions was the mean of the log identification thresholds for the three cards of each type; the log scores were used to increase the normality of the distribution of scores and reduce the large variability.

For the incongruous cards, the comparison of Groups N-TM and R-TM with Group N-N was significant in the predicted direction [$F(1,57) = 11.27$, $MSe = .20$, $p < .01$, $\omega^2 = .14$]; the comparison of Group N-TM with Group R-TM was not significant [$F(1,57) = 1.86$, $MSe = .20$, $p > .05$]. For the normal cards, neither of the two comparisons was significant [$F(1,57) = .70$, $MSe = .003$, $p > .05$, for N-TM and R-TM vs. N-N; $F(1,57) = .008$, $MSe = .003$, $p > .05$, for N-TM vs. R-TM]. The significant improvement in performance for incongruous cards among Groups N-TM and R-TM, and the other group data for this task, are charted in Figure 3 in terms of the original nontransformed scores.

An inspection of the means of Figure 3 indicate that the hypothesis was not adequately tested for conventional playing cards. The initial threshold scores for these stimuli were so close to the minimum value of 10 msec that no effects could be assessed. However, the initial means for the incongruous cards were sufficiently high to insure that intervention effects were able to be measured.

Thus, the results for the card identification task for incongruous cards are consistent with the hypothesis that repeated reduction of conceptually driven mental activity during the TM technique over time allows individual perceptual performance to be less bound or restricted by habitual patterns or schemata. The parallel slopes for Groups N-TM and R-TM in Figure 3 indicate that there was no additive effect of regular daily relaxation on the identification of incongruous cards.

Longitudinal Anagram Effects

Hypotheses 3 predicts that subjects practicing the TM technique for 2 weeks show, in contrast to relaxation or control subjects, a reduction in solution time to anagrams of both high and low bigram frequency. The data did not support this hypothesis. There were no significant effects associated with either TM participation or relaxation.

The anagram data were tested by a 3 (groups) by 2 (anagram conditions) by 3 (trials) factorial ANOVA of unweighted means, performed on the square root transformed solution time scores. The Group by Trial

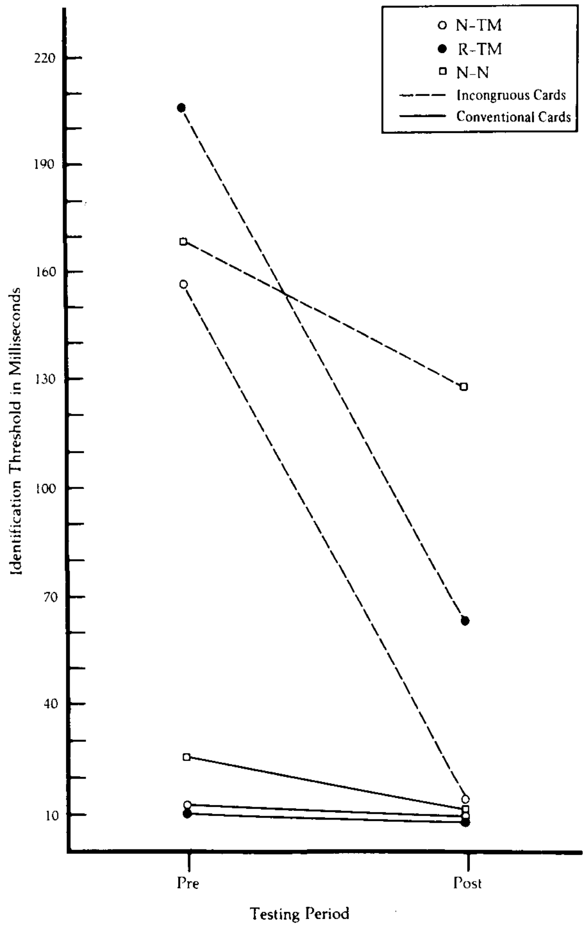

Figure 3. Mean of untransformed card identification thresholds for conventional and incongruous playing cards before and after a 4-week period in which subjects practiced the TM program for the second 2 weeks (N-TM) practiced relaxation for 2 weeks and then the TM program for 2 weeks (R-TM), or added no practice (N-N).

interaction predicted by the third hypothesis was not found [$F(4,128) = 1.01$, $MSe = 3.02$, $p > .05$]. However, several effects were significant in this ANOVA. There was a significant Anagram Condition by Trials interaction [$F(2,128) = 12.55$, $MSe = 1.99$, $p < .001$, $\omega^2 = .15$]. As indicated by the data of Figure 4, this interaction indicated that anagrams composed of low-frequency bigrams were less difficult to solve for the first and second sessions, as found by prior research, but more difficult to solve on the third session. When all three trials were combined, the anagrams composed of low-frequency bigrams were less difficult to solve, as expressed in a significant main effect of anagram condition [$F(1,64) = 4.87$, $MSe = 1.95$, $p < .05$, $\omega^2 = .05$]; group means of transformed scores were 7.01 and 7.32, respectively, for anagrams of low and high bigram frequency. Taken together, these significant effects indicate that although, as expected, anagrams of low frequency were easier to solve for the first two sessions, there was substantial uncontrolled variance on the stimuli of the third session, resulting in a reversal of this usual effect.

The two other main effects for the ANOVA of anagram performance were also significant [for trials, $F(2,128) = 53.60$, $MSe = 3.02$, $p < .001$, $\omega^2 = .44$; for groups, $F(2,64) = 3.77$, $MSe = 15.81$, $p < .05$, $\omega^2 = .07$]. The main effect of trials was probed by Duncan's multiple-range test, which showed that all three trials differed significantly from each other at the .05 level. The trial means of the transformed scores were 7.13, 6.08, and 8.29 for Trials 1-3, respectively; this indicates that the task was not stable over repeated testing. When the main effect of groups was also probed by the more conservative Duncan test, none of the three groups differed at the .05 level; however, the group means of transformed scores, which were 7.94, 6.78, and 6.78 for Groups N-N, R-TM, and N-TM, respectively, indicate that Group N-N performed less well overall.

In contrast to the perceptual findings, parallel effects for the verbal problem solving task, predicted to result from regularly experiencing reduction of mental activity during the TM technique, were not evident. It may be that the development of flexibility of interaction between conceptually driven and data-driven processes, presumed here to give rise to the effective application of schemata to new information, is evident first on perceptual tasks, in which the data-driven processes are more dominant

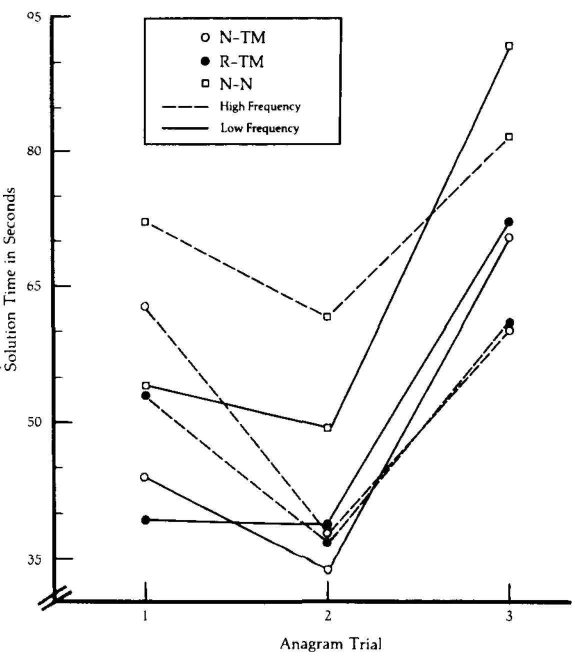

Figure 4. Mean of untransformed solution times for anagrams composed of either low or high bigram frequency. During the first 2-week period, subjects either practiced relaxation (R-TM) or added no procedure (N-TM and N-N); during the second 2 weeks, subjects either practiced the TM technique (N-TM and R-TM) or added no practice (N-N).

than in the verbal problem solving task. However, whether a longer period of practice of the TM technique would affect anagram performance remains untested.

In summary, the results overall are consistent with the hypothesis that a reduction of conceptually driven mental activity during the TM technique results in improvement both on task conditions in which habitual perceptual schemata aid performance and on task conditions in which they either do not aid or actually hinder performance. Evidence was found for this effect both immediately after meditation and over a 2-week period for perceptual tasks, but such evidence was not found for the verbal problem solving task. These perceptual results were generally the same for both the measures d′ and p(D|s) on the letter identification task and, thus, do not appear attributable to initial differences between the groups on the measure p(D|s), nor do those effects appear attributable to changes in response bias (β). In contrast, relaxation appeared to have an immediate effect of increasing performance only for the word-like sequences of the letter identification task, that is, increasing performance only when performance would be aided by the activation of habitual perceptual schemata. No longitudinal effect of relaxation was evident. These results thus support the theoretical suggestion of an integrated perceptual style characterized by the coexistence of dishabituation and increased effectiveness.

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