MEDITATION CAN REDUCE HABITUAL RESPONDING
Heidi Wenk-Sormaz, PhD

Context • Although cognitive aspects of meditation underlie much of its clinical application, very little research has examined meditation's cognitive consequences. This investigation provides experimental support for the idea that meditation leads to a reduction in habitual responding using randomly selected subjects, a secular form of meditation, and a full experimental design.

Objective • To test the hypothesis that meditation leads to a reduction in habitual responding.

Design • Studies 1 and 2 each incorporated pre-test and post-test designs with a 20-minute intervening attention task (meditation, rest, or a cognitive control).

Setting • Yale University in New Haven, Conn, and the University of California, Berkeley.

Participants • One hundred and twenty and 90 undergraduates participated in Studies 1 and 2, respectively.

Main Outcome Measures • Stroop and Word Production (category generation and stem-completion) tasks assessed habitual responding in Study 1. Galvanic Skin response measured arousal in Study 1. The category generation task assessed habitual responding in Study 2. Tellegen's Absorption Scale (TAS) measured attention ability.

Results • In Study 1, meditation participants showed a reduction in habitual responding on the Stroop task as compared to controls. Study 1 revealed no statistically significant effects in the word production task. Stroop task performance was not mediated by arousal reduction. In Study 2, meditation participants showed a reduction in habitual responding on the category production task. Specifically, when participants generated either typical or atypical items, on average, meditation participants produced more atypical items than controls. Category production performance was not mediated by Tellegen's Absorption Scale (TAS) scores. Overall, high TAS scores were related to atypical responding.

Conclusion • Across cognitive tasks, when participants understood that the goal was to respond non-habitually, meditation reduced habitual responding.

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Meditative practices from Eastern traditions (eg. Buddhist meditation, yoga, transcendental meditation, etc) have become widely accepted as strategies for self-regulation and primarily, stress reduction. Within the field of psychology, the focus of meditation research has been physiological change and the reduction of medical or psychological symptoms of stress or both. After decades of research, most investigators agree that meditation practice reliably reduces physiological arousal and psychological anxiety. Likewise, to the extent that a clinical problem is exacerbated by stress, it is thought that meditation can serve as a helpful intervention. Specifically, experimental work has shown meditation to be effective in the treatment of chronic pain, hypertension, insomnia, clinical anxiety, irritable bowel syndrome, psoriasis, fibromyalgia, and asthma.

Meditation is similar to other self-regulation techniques, such as biofeedback and progressive relaxation training, in that they all involve a conscious attempt to control attention. Given that the main component of self-regulation is cognitive attention control, it is surprising that there has not been a broader investigation of the cognitive consequences of engaging in meditation. The cognitive aspects of meditation underlie some of its clinical applications. Moreover, cognitive change is what Eastern practitioners have concentrated on for centuries. The focus of this investigation is to examine meditation in cognitive terms.

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Historically, meditation practice has been associated with cognitive change. Specifically, it has been suggested that meditation practice leads to a higher state of awareness\(^{12}\) or may help a practitioner gain insight and understanding into psychological problems and the workings of the mind. Across religions and practices, it is generally believed that meditation leads to a minimization of or reduction of thinking and conceptual activity that allows the practitioner to experience the world without cognitive bias, filters, or models built up from past experience.\(^{13,15}\) For example, after meditation, the practitioner should be able to approach a typically stressful situation, such as getting stuck in traffic, with a new perspective or response, such as realizing that being stuck gives him or her extra time to talk with his or her child in the backseat. The idea is that the automatic and typical reaction, such as swearing and brooding about disdain for the driver coming up the breakdown lane, now becomes a choice as opposed to an inevitability.

Phenomenological investigations agree with traditional accounts of the cognitive outcomes of meditation practice\(^{16-41}\) but controlled empirical evidence is lacking. In order to provide a basis for clinical and psychological applications of meditation as a cognitive intervention, further experimental examination of the cognitive effects of meditation is warranted. Thus, this investigation attempts to further experimental examination of the cognitive effects. Two studies test the hypothesis that meditation leads to a deautomatization or reduction in habitual patterns of cognitive performance. Stroop and Word Production (category generation and stem-completion) tasks were employed in pre-test/post-test designs with an intervening attention task (meditation, rest, or a cognitive control). Study 1 examined whether or not meditation practice led to non-habitual responding. Study 2 examined whether the meditation-induced ability to respond in a non-habitual way was optional, or if engaging in meditation impaired habitual responding. Before presenting the framework from which this research follows, deautomatization, it is necessary to explain what researchers in the field of experimental psychology accept as a definition of meditation and the most common approach to cognitive meditation research.

**MEDITATION AS A TOPIC OF RESEARCH IN COGNITIVE PSYCHOLOGY**

In 1982, Shapiro provided the conventional operationalization of meditation for the American Psychiatric Association. Meditation was proposed to be a "family of techniques which have in common a conscious attempt to focus attention in a non-analytical way, and an attempt not to dwell on discursive, ruminating thought."\(^{42}\) The most widely researched meditation technique is transcendental meditation (TM). TM practice requires a focus of attention on the silent repetition of a mantra (a single syllable, such as *om*) while practitioners maintain a passive disregard for any thoughts that might occur during the session. Much of the TM research suggests that meditation practice leads to a change in cognitive function.

At the same time, many investigators are skeptical of TM research primarily because TM was developed within a religious or spiritual tradition, which entails subject-selection problems. In addition, the general nature of the theory behind TM research, predicts that TM makes the practitioner better at a multitude of tasks.\(^{43}\) Generated publications appear suspicious because they commonly include broad conclusions, quotations from the teachings of the Maharishi, and uniformly positive findings. An example of the latter is that TM claims to give practitioners access to higher stages of consciousness; reduce drug usage; provide relief from anxiety, neurotic, and psychosomatic disorders; improve concentration, creativity and self-actualization; increase intelligence, energy, and productivity; enhance personal relationships; and even reverse biological aging.\(^{44}\) The focus of this investigation is to replicate and to extend some of the findings of the TM research using randomly selected subjects, a secular form of meditation, a full experimental design, and a basis in psychological theory.

**DEAUTOMATIZATION**

As mentioned, traditional accounts of meditation suggest that practice will lead to a reduction in habitual cognition. Deikman, one of the earliest experimental psychologists to examine meditation, referred to this as deautomatization.\(^{33,45,46}\) Specifically, Deikman derived a three-fold, deautomatization hypothesis proposing that concentrative meditation led to 1) mystic experiences, 2) the development of barriers against distraction, and most important, 3) "partial deautomatization of the psychic structures that organize and interpret perceptual stimuli."\(^{47,48}\) We will focus on the third of Deikman's predictions, primarily because it aligns with traditional accounts of meditation and has some empirical support. Specifically, the deautomatization hypothesis predicts that meditation practice should minimize biasing or habitual conceptual activity through the interruption or undoing of automatic processes.

Unfortunately, Deikman did not provide a specific operationalization of deautomatization. Likewise, psychological models of automaticity do not include an operationalization of the undoing of an automatic process. Both Deikman and proponents of early models of automaticity described automatization as the process that occurs with the repetition of an action or behavior wherein the intermediate steps of the behavior disappear from consciousness awareness.\(^{49-50}\) Deikman went further to suggest that deautomatization was the reverse of automatization, presumably achieved through reinvesting attention in actions and experiences. This suggestion of deautomatization as a reinvestment of attention into a behavior is consistent with both early models of automaticity, equating automaticity with a lack of attention,\(^{47,48}\) and more recent models, equating automaticity with a transition from general or algorithmic processing to memory retrieval.\(^{50-52}\) All accounts allow for deautomatization through the manipulation of input cues. If an individual reinvests attention into an action, the relevant information that is encoded may change. It follows that
memory or information retrieval processes would be altered, and there would be the possibility of an interruption of the previously automatic behavior. Specifically, all of the models would require an attention focus on the uncommon features of a common experience (for example, when looking at a face, a focus on the color of the eyes instead of the face as whole). Interestingly, all types of meditation incorporate the direction to focus attention on an aspect of experience that is typically overlooked. For example, people do not typically attend to the physical sensations associated with breathing, and even when they are noticed, they are subsequently ignored. The basic requirement of a traditional Zen meditation on the breath is to attend to these sensations for an extended period of time. Deikman’s suggestion of deautomatization through a reinvestment of attention into an automatic activity conforms precisely to the instructions given to meditators.

To illustrate how conscious attention to a situation can alter a person’s habitual response, consider Luchins’ classic water jar experiments. In these experiments, participants are given a set of problems that can all be solved with an algorithm. Once participants have learned the algorithm, they continue to use it for the entire set of problems, even when later problems are solvable through the use of a less complex method. Interestingly, when participants were specifically told to pay more attention to what they were doing, they sometimes will not fall into the fixed pattern of responding. More recent experimental evidence comes from Langer and Weinman. Measuring the insertion of pauses and “ums” in speech patterns, they found that when participants were asked to perform a habitual activity, speaking about a topic frequently spoken about, the addition of an attention requirement that participants think about the topic further prior to performance disrupted their speech (disrupted their typical performance). At the same time, when participants were asked to speak on a topic that was unfamiliar, time to think about the topic improved their performance. Thus, extra attention does not disrupt all speech patterns, instead extra attention to the details of an over-learned topic can disrupt a previously habitual response.

In addition to a change in input cues due to the deliberate control of attention, another way in which meditation may lead to deautomatization follows from one of the most consistent findings in meditation research. That is, it is widely established that meditation leads to a reduction in arousal. Easterbrook, and later, Broadbent hypothesized that high arousal leads to increased attention selectivity. Conversely, when arousal is reduced, more things are attended but none is attended very strongly. Experimental support for these ideas came from a variety of early investigations. Thus, arousal reduction and the instructions given to meditators may lead to a similar outcome. If meditation results in lower levels of arousal that is associated with a wider sampling of the environment, again atypical memories may be cued, inhibiting or interfering with automatic responding.

**Experimental Support for Deautomatization**

The idea that meditation can reduce habitual conceptual activity finds support in the empirical work of a number of investigators studying the effects of TM practice. In these investigations, TM has led to a reduction in habitual performance when the option for the participant is to respond typically or atypically. For example, reading a word versus naming the color of a word, or identifying playing cards that are typical or have the color and suit reversed (e.g., a red 6 of clubs).

A more complicated task, the Star Counting Task (SCT) can also be viewed as evidence for deautomatization. The SCT requires that participants count stars that are presented in rows on a page. Deautomatization comes into play in two ways. First, the task requires switching from a habitual form of counting (forward) to a non-habitual form of counting (backward). Second, the meaning of plus and minus signs are reversed in the second section of the test such that the plus sign means to count backward and the minus sign means to count forward. Two investigations found that after meditation, TM practitioners performed better on the SCT than controls.

As mentioned previously, there are findings in the literature on the effects of meditation practice that appear to be atheoretical. These include improvements in simple and choice reaction time, increases in intelligence, creativity, and changes in personality reflecting an increase in overall positive mental health. Because deautomatization is a general process, it is possible that it may underlie some of the seemingly atheoretical findings. For example, some definitions of creativity are similar to deautomatization in that they assume an ability to go beyond the typical or habitual response for a certain context. In the future, analyzing or designing tasks with deautomatization in mind may help clarify the experimental findings.

In sum, Deikman’s concept of deautomatization may be the most coherent framework from which to work because it can be derived from the cognitive predictions of religious meditation, it aligns with some accounts of the cognitive and attentional effects of arousal reduction, and there already exists some supporting evidence for the hypothesis. Therefore, this investigation draws on the deautomatization framework to assess more precisely the influence of meditation on habitual cognitive and attentional processes. In the studies that follow, standard cognitive tasks (the Stroop and Word Production tasks) that can assess habitual and non-habitual responding are employed. If engaging in meditation leads to deautomatization or a reduction in habitual patterns of response, participants who meditate are predicted to show less habitual responding on these tasks than participants in control conditions. These studies differ from previous investigations in that they incorporate participants who have never practiced meditation, the use of a secular form of mediation, and a controlled experimental design with random assignment of participants into meditation and control conditions. Study 1 examined release from habitual responding in two tasks following 1 of 3
attentioal-instruction conditions. Study 2 examined the possibility that meditation specifically reduces habitual responding only when habitual responses are not optimal.

STUDY 1

This study attempts to partially replicate the results of Alexander et al and Rani and Rao, while controlling for the demand characteristics involved in employing participants who practice TM. Previous research showed that TM practice led to a reduction in habitual patterns of response on the Stroop task. TM is a concentrative meditation with the focus of attention on a mantra that is silently repeated in the rhythm of the practitioner’s breath. In both TM and the secular form of meditation used here, the general instructions given to the meditator are to pay close and continuous attention to a meditation object (in this study, the breath), and every time one notices that awareness has shifted away from the object of meditation, to return attention to it.

This study employs two tasks to measure habitual cognition. First, the Stroop task was used in order to extend previous findings on an over-learned task, word reading. This task is designed to assess the ability to inhibit habitual responding, word reading, and instead bring attention to a non-typical aspect of reading, noting typeface color. The second task was chosen in order to better understand the cognitive consequences of engaging in a meditation technique. A word production task incorporating category production and word-stem completion was used to enable measurement of the distribution of information available to a participant after meditation. If meditation reduces habitual patterns of responding, the distribution of responses elicited by category descriptions and word-stems after meditation should be more variable and less typical than the responses elicited in the control conditions. In addition to the cognitive tasks, Study 1 incorporated a measurement of arousal. It is possible that any cognitive effect of meditation may be mediated by physiological relaxation. In other words, meditation may not directly alter cognition. Instead, meditation may lead to a reduction in arousal that affects how an individual takes in information from the environment, cuing atypical memories, and altering response patterns. If this is the case, any technique that reduces arousal should lead to non-habitual responding. To address this concern, Galvanic Skin Response (GSR) was measured during the attention strategy (meditation, rest, cognitive control) to assess the relationship between arousal and level of habitual responding.

Both tasks incorporated a pre-test/post-test design with 20 minutes of an intervening attention procedure (meditation or 1 of 2 control conditions). Although the treatment procedure is of a short duration, a typical TM session is 20 minutes. Each participant was randomly assigned to a condition and participated in a single task. It was predicted that the meditation group would show evidence for deautomatization. Specifically, on the Stroop task, it was predicted that the meditation group should show less interference from the habitual response, word reading, on their ability to name the color of words. On the Word Production task, the meditation group should produce more variable and less typical responses than controls. Because cognitive changes are initially said to occur during meditation, participants were tested immediately after meditating. It should be noted that there is no empirical evidence demonstrating how much meditation is necessary in order to produce a desired effect.

METHOD

Participants

Participants were 120 (44 male, 76 female) Yale undergraduates who received Introductory course credit or were reimbursed for their time. The average age of the participants was 19.47 years (SD = 1.92). In all, 132 participants were recruited for the experiment, but 10 were unable to complete the required 3 sessions, 1 participant failed to follow directions, and 1 participant’s arousal data was not recorded due to a technical difficulty. The attrition rate across attention strategy groups was as follows: 3 meditation group participants, 6 learning group participants, and 1 rest group participant.

Participants were randomly assigned to attention procedures and cognitive tasks. The Stroop and Word Production tasks each contained a total of 60 participants (20 in each attention condition of each cognitive task).

Materials: Attention Tasks

Meditation

The meditation procedure was modeled after a Zen meditation on breathing. During the 20-minute session, the participants were asked to focus their attention on the fact that they were breathing, and when they found themselves thinking about other things, to return their attention to their breathing. They were told that it was natural for their mind to wander and that the goal was to continually return attention to their breathing when they noticed it had strayed. During the session, meditation participants listened to an audiocassette that reminded them of the directions. For a transcript of the tape, see Appendix A. This tape was produced in a stress-reduction course at Yale School of Nursing that teaches meditation to healthcare practitioners. A complete description of the course can be found in Kabat-Zinn.

Learning

The learning group was used as a cognitive control group for the passive disregard of thoughts employed in meditation. The learning task involved concentrated attention while specifically generating thoughts. The learning strategy consisted of using a mnemonic device, the method of loci, to learn a list of items. The participants of Yale University. Participants were instructed to construct a visual image of the place where they lived and to try to find a way to represent all of the names within that visual space. For exact directions, see Appendix B.
Rest

To control for concentrating attention, the participants in the rest group were told to sit, rest, and let their minds wander for 20 minutes.

Participants in all 3 conditions were informed that they may have their eyes open or closed but to try to remain awake.

The Stroop Task

This task required participants to name the color of items when those items were either strings of Xs or a word that was the name of a color printed in a colored typeface. The colors and words included in the task were red, green, blue, and orange. The task included 16 practice trials (8 of Xs and 8 of words) followed by 4 blocks of experimental trials (2 of Xs and 2 of words). Within a block, participants performed 48 trials. Word blocks contained 12 congruent (typeface color and word were the same) and 36 incongruent (typeface color and word were different) trials.

On every trial, the participant viewed a fixation point (+) for 500 ms followed by the appearance of a word or a string of Xs 100 milliseconds (ms) later. The participants said the name of the color of the item aloud as quickly and as accurately as possible. If the participant did not respond within 1,750 ms, the trial was counted as an error. The participant’s response initiated the next trial with an intertrial interval of 1,000 ms. The participant had an opportunity to take a break in between blocks. A review of the high reliability and validity of the Stroop task can be found in MacLeod. 78

Blocks of Xs and words were alternated and counterbalanced at both pre- and post-test. In pre-test, half of the participants began with Xs and half began with words. The pre-test order was reversed at post-test. The two orders were counterbalanced across participants within attention conditions. Practice trials were performed prior to both pre- and post-testing.

Word Production

Participants performed category production and word stem completion in the same experimental session. During pre- and post-test, participants received 10 category descriptions and 10 word-stems. There were two sets of each type of item, for a total of 20 categories and 20 word-stems. In order to construct the sets (A and B), 20 category descriptions from Battig and Montague and 20 word-stems from Graf and Williams were chosen. 79,80 (See Appendix C.) The category sets A and B were matched according to the 1969 norms on the number of different responses that were provided with a total frequency of 10 or more. Similarly, the word-stem sets A and B were matched according to the 1987 norms on the number of different words provided as a first completion.

The sets of items were counterbalanced as to whether they occurred first or second in the testing session (category production before word-stem completion or vice versa) and which set (A or B) occurred at pre- or post-test. Participants never received a particular category description or word-stem more than once.

In the category production task, participants were presented with 10 category descriptions. Each description appeared on the top of a sheet of paper in a booklet followed by 20 response spaces. The participants were asked to generate items that belonged to each category within 30 seconds. The timing of the task was based on Battig and Montague, 79 so that the original norms could be used in the data analysis. Participants were instructed to fill in the spaces in order as the response items were generated. The experimenter told the participants when to advance to the next category. For the specific task directions, see Appendix D.

In the word-stem completion task, participants were presented with 10 word-stems. The same 3-letter, word-stem appeared 6 times on each page of a booklet. The participants were given 1 minute per page to fill in the spaces with English words beginning with the given word-stem. The timing of the task was based on Graf and Williams 80 so that the original norms could be used in the data analysis. Participants were told to fill in the spaces in the order that the items were generated. The experimenter told the participants when to advance to the next page. For the specific directions given to each participant, see Appendix D.

Arousal Measurement

During the attention task in the experimental session, arousal was measured by monitoring skin conductance (GSR). In order to do this, two bands, each attached to an electrode, were placed on the third and fourth fingers of the participant’s right hand. Lafayette instruments electrode gel was used as an electrolyte. As is standard in this type of psychophysiological recording, an imperceptible amount of electricity passed between the electrodes. The current was safe and undetectable. Appropriate amplifiers and filters (designed by BIOPAC Systems Inc) detected skin conductance and passed the data to a Macintosh computer for display and processing in AcqKnowledge III. Before beginning the experiment, the participant was reassured that the physiological measurement involved no risk.

GSR was recorded during the first and last 3 minutes of the 20-minute interval at 200 samples per second. Measurements were recorded in μmhos (micro inverse ohms) and analyzed as the average μmhos across the interval.

PROCEDURE

Participants were recruited and assigned to 1 of the 3 attention conditions (meditation, learning, or rest) and to either the Stroop or Word Production tasks using block randomization. The experiment contained 3 sessions. During each of the first 2 sessions, the experimenter taught the participants their assigned attention technique and the participants practiced the technique for 20 minutes. During the final session, participants engaged in the experimental task before and after engaging in the attention technique. GSR was measured during performance of the attention technique. When participants...
completed the experiment and had been given credit or were reimbursed for their time, they were asked about their performance of the attention technique. First, they were asked if they fell asleep. Next, participants were asked to rate how much effort they had put into following the directions of the attention technique: On a scale of 1 to 10, how much were you trying to follow the directions throughout the 20-minute attention task? On the scale, 1 represents not at all and 10 represents 100%. Finally, participants were asked if they had any comments or concerns about the experiment.

The first two sessions required approximately 30 minutes each and the final session took 1 hour. All participants finished the 3 sessions within 2 weeks. The experimenter attempted to schedule the 3 sessions as close together as possible (although on different days). At the end of the third session, all participants were given the opportunity to learn any of the attention procedures they had not been assigned.

RESULTS

Arousal

Participants’ GSR was measured during the first and last 3 minutes of the 20-minute attention task on the final testing day. Means for each time period were taken by averaging the level of arousal across each 3-minute interval. The relevant measure was the percent change in the mean level of arousal (in μmhos) produced by the attention strategy, referred to as arousal percent difference (APD). Overall levels of GSR are not informative because they vary from person to person based on factors irrelevant to this investigation, such as skin thickness.

Due to technical error, GSR for 1 meditation participant in the word production task was not recorded. In all analyses of the cognitive tasks, the measure was replaced with the group average (mean) of that participant’s attention and task condition. It should be noted that the replacement did not affect the statistical significance of any of the findings, but does permit balanced statistical analysis.

Table 1 provides the APD data (means and standard deviations) across experimental group and cognitive task. Negative APD values denote a reduction in arousal, whereas positive values denote an increase in arousal. In both tasks, participants in the meditation group showed reduced levels of arousal as compared to the learning and rest control groups. A planned contrast predicting that the meditation group would show a larger reduction in arousal than the learning and rest groups (weights -2, 1, 1) was statistically significant for the Stroop and Word Production tasks, t(57) = 2.82, P < .01, and t(57) = 2.38, P < .05, respectively.

This reduction in arousal shown by the meditation group is consistent with previous investigations of the physiological effects of meditation. Given that this difference was found and that we were primarily interested in the cognitive effects of meditation, APD was incorporated into the analyses below as a covariate to permit assessment of cognition beyond that attributable to arousal reduction. Specifically, all of the analyses conducted in Study 1 were performed with and without APD as a covariate.

THE STROOP TASK

All analyses reported below used post-test scores as the dependent variable. This was appropriate because of the random assignment of individuals to attention conditions. Stroop interference was calculated for each participant by subtracting the mean baseline score, the reaction time (RT) of the X trials, from the mean of the incongruent trials. The facilitation effect was calculated as the subtraction of the mean baseline RT from the mean of the congruent trials.

The overall level of error was very low, 3.13%. A 2x3 analysis of variance (ANOVA), grouped by condition (baseline, congruent, incongruent), revealed a main effect of condition where participants made the fewest errors in the congruent condition (mean = .32) followed by the incongruent condition (mean = 1.41) and finally, participants made the most errors in the baseline condition (mean = 1.71). There was no evidence of a speed-accuracy trade-off.

Table 2 presents the mean reaction times across attention conditions at post-test. All of the analyses conducted on the data incorporated ratio scores of the original measures such that the overall speed of responding was taken into account. To do this, each measure was divided by the baseline speed of responding. It should be noted that in all of the subsequent analyses, changing the scoring to a ratio measure did not change the statistical significance level of the reported effects.

Table 3 displays the effects of Stroop interference and facilitation in ratio scores as a function of experimental condition at post-test. Standard deviations are in parentheses. There were no between-group differences in pre-test performance on any of the reported measures. In an examination of the Stroop

<table>
<thead>
<tr>
<th>TABLE 1 Arousal Percent Difference Values Across Task and Attention Condition in Study 1</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Task</td>
<td>Meditation</td>
</tr>
<tr>
<td>Stroop</td>
<td>- 9 (56.9)</td>
</tr>
<tr>
<td>Word Production</td>
<td>- 13.5 (63)</td>
</tr>
<tr>
<td>Standard deviations are in parentheses</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2 Mean Reaction Times Across Attention Condition in the Stroop Task of Study 1</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td>Meditation</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>Baseline</td>
<td>618.5 (74.8)</td>
</tr>
<tr>
<td>Congruent</td>
<td>651.5 (89.9)</td>
</tr>
<tr>
<td>Incongruent</td>
<td>711.2 (79.3)</td>
</tr>
<tr>
<td>Standard deviations are in parentheses</td>
<td></td>
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</tbody>
</table>
interference ratio scores, meditation participants produced a numerically lower level of interference than the control groups. Given that the original prediction for the three groups was that the meditation group would show less interference than the other two groups, a planned contrast (weights = -2, 1, 1 for meditation, learning, and rest groups, respectively) was used to assess between-group differences. This result was statistically significant, \( t(57) = 2.01, P < .05 \). When APD was added as a covariate, the planned contrast (weights as described above) on the analysis for covariance (ANCOVA) was also statistically significant, \( t(56) = 2.28, P < .05 \). Thus, meditation led to a reduction in Stroop interference. In addition, this reduction was not mediated by a reduction in arousal.

In an examination of the facilitation ratio scores, a planned contrast comparing the meditation group to the other two groups (weights = -2, 1, 1 for meditation, learning, and rest groups, respectively) failed to reach statistical significance \( t(57) = .81, \) not significant (ns). When APD was added as a covariate, the pattern of a lack of statistical significance did not change \( t(56) = 1.38, \) ns. Meditation led to reduced interference but not reduced facilitation in Stroop task performance. Meditation participants were better able to inhibit automatic response (word reading) when it ran counter to the task objective, but did not inhibit that response relative to the other groups when the information was useful.

**Word Production**

In the word-stem completion task, participants' responses were quantified with the norms from Graf and Williams. Specifically, the item produced was replaced with the frequency of that response from the 1987 data. Thus, high values indicate frequent or typical responses, and low values indicate atypical or infrequent responses. Two scores were calculated for each participant. "First frequency" was the frequency of the first item the participant generated. This was singled out because there are fewer constraints on the first item generated than on the remaining items. This measure literally reflects the first thing that comes to mind. Second, average frequency was calculated across all of the responses the participant generated.

In the category production task, participants' responses were quantified with the norms from Battig and Montague. Just as with the stem completion data, the item produced was replaced with the frequency of that response from the 1969 data. Again, first frequency and average frequency were examined.

Table 4 presents the means and standard deviations of first frequency and average frequency across the three groups in the stem completion task at post-test. There were no between-group differences in pre-test performance on any of the reported measures in stem completion and category production.

In the stem completion task, it was predicted that the meditation group would produce items with lower first and average frequencies than the other two groups. Planned contrasts were not conducted on the frequency measures because the group means were not in the predicted direction. A similar pattern of data was found in the category production task. Table 5 presents the means and standard deviations of first frequency and average frequency across the three groups for category production at post-test. A planned contrast was conducted on the first frequency measure because the group means were in the predicted direction but the contrast (weights were -2, 1, 1) failed to reach statistical significance, \( t(57) = .81, \) ns. When APD was used as a covariate, a planned contrast (weights -2, 1, 1) on the first frequency measure also failed to reach significance, \( t(56) = .79, \) ns. Given that the average frequency means were not in the predicted direction, contrasts were not conducted on that measure. In sum, there was virtually no evidence for deautomatization in the word production task as a result of attention training.

**Arousal and Deautomatization**

It has been suggested that increasing levels of arousal might lead to stereotypical responding. In order to assess that claim, linear relationships between APD and the cognitive variables employed in this experiment were examined. Table 6 presents the correlations (\( r \)) between participants' APD and cognitive scores.

**TABLE 4 Word-Stem Completion Frequency Across Attention Condition in Study 1**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Meditation</th>
<th>Learning</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Frequency</td>
<td>47.2 (8.2)</td>
<td>44.1 (11.7)</td>
<td>49.0 (8.7)</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>36.8 (2.4)</td>
<td>35.3 (6.8)</td>
<td>37.2 (4.2)</td>
</tr>
</tbody>
</table>

Standard deviations are in parentheses. Note: A high number denotes a more typical or habitual response.

**TABLE 5 Category Production Frequency Across Attention Condition in Study 1**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Meditation</th>
<th>Learning</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Frequency</td>
<td>263.7 (41.6)</td>
<td>277.3 (43.5)</td>
<td>269.0 (43.8)</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>180.3 (21.8)</td>
<td>178.1 (16.8)</td>
<td>176.6 (16.8)</td>
</tr>
</tbody>
</table>

Standard deviations are in parentheses. Note: A high number denotes a more typical or habitual response.

Note: A high number denotes a more typical or habitual response.
Two statistically significant linear correlations emerged, and they were in the opposite direction of the predicted result. APD was negatively correlated with average frequency in category production and first frequency in stem completion. In both cases, as participants’ arousal levels increased, their productions were significantly less typical. The direction of these findings was unexpected. It appears from the analyses of the linear relationships between APD and the cognitive variables that increase in arousal led to less stereotypical responding. At the same time, these findings may have been due to chance. There were only two statistically significant findings out of a total of 32 possible relationships (approximately 6%).

Although the analysis of linear relationships does not provide any evidence for a linear relationship between arousal and habitual responding, it is possible that there was a non-linear relationship. Visual inspection of the scatterplots for all of the possible relationships presented above revealed no specific curvilinear aspects or oddly shaped distributions. In all, there is no evidence that increasing arousal leads to more typical responding. If anything, the opposite pattern emerges. More importantly, performance on the task showing the most reliable results, the Stroop task, did not reveal any relationship to APD.

### Effort

As mentioned previously, at the end of the experiment, participants were asked to rate how much effort they had put into following the directions of the attention technique. (On a scale of 1 to 10, how much were you trying to follow the directions throughout the 20-minute attention task? On the scale, 1 represents not at all and 10 represents 100%). Table 7 presents the mean effort ratings across groups and attention tasks (standard deviations in parentheses). In addition, the level of statistical significance across the meditation, learning, and rest groups is presented. Amount of perceived effort cannot account for the results. The Stroop task revealed between-group differences in performance but not on the measure of effort during the attention task, whereas there were no between-group differences for the word production task but differences emerged on the measure of effort during the attention task. It was not the case that cognitive effects were found only when group differences in attention task effort were found. It appears that the meditation participants reported putting less effort into the attention task than the learning group and the rest group. This finding is interesting because participants in the meditation group put less effort into the attention task, yet there was still an effect on Stroop performance. This effect may be smaller than might have otherwise been achieved if participants had put more effort into the attention task.

### DISCUSSION

Based on prior research and predictions of cognitive change from traditional forms of meditation practice, this investigation hypothesized that meditation practice might lead to deautomatization or a reduction in habitual patterns of response. Mixed support for the hypothesis was found. Study 1 revealed that engaging in meditation practice led to a reduction in Stroop interference. Although this Stroop performance may reflect deautomatization, if meditation led to generalized deautomatization, per se, the predicted effects for the word production task should have emerged as well. There were no between-group differences on the word production task.

In addition to a reduction in Stroop interference, engaging in meditation led to a reduction in arousal. Interestingly, this reduction in arousal did not account for the deautomatization seen on the Stroop task. When arousal was incorporated as a covariate, the reduction in Stroop interference shown by the meditation group over the control groups remained. In addition, when the relationship between arousal and cognitive performance was examined, correlations were not indicative of a claim that a reduction in arousal leads to less typical performance. Instead, when statistically significant correlations were found, high arousal reflected less typical responding.

The results of Study 1 evoke the question: why is deautomatization shown in the Stroop task, but not in the word production task? One of two interpretations is likely. First,
meditation effects may be primarily due to a change in the ability to attend selectively. This is based on the idea that Stroop task can be considered an attention task (the ability to selectively attend to the color) whereas the word production task cannot. Given that meditation practice is the retraining of attention, it should not be surprising that meditation might influence performance on an attention task. Positive results in the Stroop task coupled with a lack of significant results in the word production task suggests that meditation (or at least the initial effects of meditation—3 sessions) does not necessarily lead to atypical responding but may result in a deautomatization of attention.

A second interpretation of the results is that a reduction in habitual responding is shown only when non-habitual or atypical responding is optimal for performance. The action of naming the color in the Stroop task is an atypical response. Naming the word is much more typical because reading is a highly automatic skill. Therefore, in the case of the Stroop task, the action required by the experiment was the atypical response. On the contrary, participants in the category task may have believed that optimal performance meant generating typical or popular items. Study 2 was designed to examine whether an instruction to produce atypical responses in the word generation task can be carried out more efficiently with meditation.

**STUDY 2**

The purpose of Study 2 was to test the idea that meditation leads to a deautomatization of response only when participants understand that an atypical response is the desired response. Study 2 examined the category production task again but changed the instructions to participants such that they were requested to specifically produce typical (habitual) or atypical (non-habitual) responses. In addition to the examination of the typicality of responding, an attempt was made to assess the relationship between attention ability and cognitive performance. It is possible that individuals who maintain a meditation practice or who perform well when asked to meditate may already possess an inherent capacity for the intention of attention. This is one reason to require the random assignment of participants in meditation experiments. Unfortunately, a good test of attention capacity or control does not exist. One self-report measure, absorption, may capture some aspect of attention that may act as a mediating variable in studies of meditation.

Absorption is typically assessed using Tellegen’s Absorption Scale (TAS). The TAS is a questionnaire that measures an individual’s ability to fully engage his or her attention in an experience, but has also been defined as a personality characteristic involving openness to new emotional and cognitive experiences. Davidson, Goleman, and Schwartz found a reliable linear increase in TAS scores from controls to long-term meditators in a cross-sectional study. Given the design of that study, it was unclear whether absorption developed or was a predisposing characteristic of long-term meditators.

More recently, in a study of meditation and hemispheric specialization, Warrenburg and Pagano found that although meditation did not lead to hemispheric specialization, performance differences that were found may have been attributable to absorption. In an examination of the attrition rate of the participants, the authors found that their novice and long-term meditators who maintained a regular meditation practice were significantly higher in absorption and in performance of a tonal memory task than the non-meditators and dropouts. Moreover, there was a significant correlation between absorption and tonal memory in the meditation group. This evidence, plus a failure to find an association between length of meditation practice and absorption, led the authors to conclude that the attention trait was not a result of practice, but possibly a predisposing variable.

Whether absorption is a predisposing variable or an ability that can be developed, investigations of the relationship between meditation and attention ought to include a measure of absorption for the purpose of gaining some statistical control over performance variability. If low absorption participants do not respond well to directions for concentrative attention, dividing the data on the basis of absorption scores may allow researchers to gain an understanding of the effects of meditation practice for these populations.

Study 2 was conducted to examine whether engaging in meditation would lead to deautomatized responses in the category production task when participants understood that the optimal response in some conditions was an atypical response. This was achieved by specifically requesting typical category items in some conditions and atypical category items in other conditions. Like Study 1, Study 2 incorporated a pre-test/post-test design (word production) with 20 minutes of an intervening attention procedure (meditation or one of two control conditions). Each participant was randomly assigned to an attention condition. Participants assigned to the meditation group performed the concentrative meditation on breathing incorporated in Study 1.

Unlike Study 1, Study 2 did not incorporate practice sessions for the attention task (meditation, learning, rest) because participant debriefing in Study 1 revealed that participants felt that the extra sessions were of little value. In addition to the cognitive task, Study 2 incorporated a measurement of TAS. It is possible that variability in the typicality of word production responses may be mediated by attention ability. In order to address this concern, TAS was measured prior to category production and used as a statistical control.

**METHOD**

**Participants**

Participants included 90 (33 male, 57 female) undergraduates from Yale University and the University of California, Berkeley, who either received payment or course credit for their participation. Initially, 95 participants were recruited, but 5 participants failed to complete the task. One excluded partici-
participant fell asleep during the attention strategy. 2 participants failed to follow directions, 1 participant’s data was lost due to a technical error, and the experimenter timed the session improperly for 1 participant.

Materials
Attention Strategies
The meditation and resting control attention strategies were the same as those used in Study 1. The resting control group controls for concentrative attention because this control group does not concentrate on anything; instead they let their mind wander. The cognitive control was different from Study 1 because the experimenter wanted more technical control over what the participant was doing in the task. In the previous task, participants used 20 minutes to mentally conduct a task (described on paper) at their own pace. The current task, answering general knowledge questions, was implemented on a computer, including specific timing throughout the 20-minute interval. As in Study 1, the cognitive control was designed to control for the passive disregard of thought. This was achieved by requesting the opposite, specifically by requiring that the group actively think and attempt to remember. Specifically, the participant sat in front of a computer screen and tried to answer a series of 96 general knowledge questions (see Appendix E). The questions appeared one at a time on the screen in front of them. Each question was displayed for 9 seconds, followed by a display of the answer for 3 seconds. The participant was instructed that the important aspect of this task was to attempt to answer the question during the 9-second interval. Similar to the rest and meditation conditions, this task took 20 minutes.

Tellegen Absorption Scale
Participants completed the Tellegen Absorption Scale (TAS), a 34-item inventory derived from Tellegen’s Multidimensional Personality Questionnaire.65 The TAS is intended to measure a person’s propensity to become involved in perceptual and imaginative experiences. An example of a question used on this scale is “If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does.”

The standard version of the scale requests that individuals rate each item as true or false but the TAS employed in this study used a 5-point Likert scale, where 0 was labeled never (had an individual experienced the item) and 4 was labeled always. Previous research shows that this new TAS scoring retains convergent validity.66 With each questionnaire item measured on a 5-point scale, the possible range of scores was 0 to 170. A higher score reflected a high capacity for absorption.

Word Production Task
In the word production task, participants received category descriptions from Battig and Montague.70 1 at a time, presented on a computer monitor. For each category description, the participant was asked to generate either 5 typical or 5 atypical items per category in 30 seconds. In all, 28 categories were used (see Appendix F). The categories were broken into 2 sets of 14 items. The category sets A and B were matched according to the 1969 norms on the number of different responses that were provided with a total frequency of 10 or more. Category sets A and B were counterbalanced for typicality across pre- and post-tests. In other words, at pre-test, a participant would generate typical responses for categories in set A and atypical responses for categories in set B. At post-test, that same participant would generate atypical responses for set A and typical responses for set B. Typicality in category sets A and B were counterbalanced across participants. During the task, the 28 items were randomly presented one at a time on the computer screen. Participants were instructed to fill in spaces on a response sheet, in order, as the response items were generated. The computer made a beeping sound when it advanced from one category to the next.

Procedure
Each participant began by filling out the TAS. Next, they completed the 28-category pre-test. This was followed by the 20-minute attention strategy (meditation, rest, or cognitive control). Finally, each participant completed the 28-category post-test. In all, this experiment took approximately 1 hour.

RESULTS
TAS Scores
Each questionnaire item on the TAS was measured on a 5-point scale. An individual’s score reflects the sum of all TAS items. A high score indicates a high capacity for absorption. TAS scores for 3 individuals are missing due to the fact that those individuals failed to complete all of the items on the questionnaire. Those 3 participants were excluded from the TAS analyses.

With the inclusion of 87 participants, the mean TAS score was 69.14 with a standard deviation of 20.68. Scores ranged from 23 to 117. Observation of the mean scores across groups shows that the meditation group appeared to have the highest TAS scores. The meditation group had a mean score of 76.24 (SD = 20.23), the cognitive control group had a mean score of 63.93 (SD = 22.7), and the rest group had a mean score of 67.13 (SD = 17.68). Although participants were randomly assigned to attention conditions, an ANOVA revealed that there was a trend toward a difference between groups in TAS scores, $F_{2,84} = 2.86, P < .10$.

Category Generation
All analyses reported below used post-test scores as the dependent variable. This was appropriate because of the random assignment of individuals to attention conditions. In the category production task, participants’ responses were replaced with the norms from Battig and Montague.70 Just as in Study 1, the item produced was replaced with the frequency of that response from the 1969 data. Again, first frequency and
average frequency were examined. Because there was a trend toward a difference between groups in TAS scores, analyses were conducted where TAS scores were used as a covariate. Specifically, this covariate was used to examine the effects of the attention strategy while attempting to control for attention ability or tendency (TAS).

Table 8 presents the mean and standard deviation of typical and atypical responses, first and average frequencies, across attention strategies at post-test. The means suggest that there is no difference in performance across the 3 groups when asked to respond typically, but there appears to be a difference across groups when the participants were asked to respond atypically. Specifically, the meditation group appeared to respond the most atypically when requested.

Table 8 reveals that meditation participants produced less typical responses in all conditions of the experiment than the participants in the control conditions. When participants were asked to respond typically, given the results of Study 2, the prediction was not clear that meditation participants would respond less typically. Therefore, an overall ANOVA was used to assess between-group differences. Analyses of both typical first and typical average frequency revealed no statistically significant differences between groups. F2,87 = .29, ns. and F2,87 = 1.09, ns. respectively. Similarly, when TAS was incorporated as a covariate, neither measure (typical first or typical average frequency) revealed statistical significance, F2,83 = .04 ns. and F2,83 = .66 ns., respectively. Thus, just as in Study 1, when participants are asked to respond typically, there were no between-group differences on the category production task.

In contrast, when participants were asked to respond atypically, we predicted that the participants in the meditation condition would be able to respond more atypically than the participants in the control conditions. Planned contrasts (weights = -2, 1, 1) were used to assess between-group differences. Analyses of both typical first and average frequency revealed statistically significant differences between groups, F2,87 = 2.62, /$ < .05. In sum, when participants know that the goal is to respond atypically, engaging in meditation increased a participant's ability to generate atypical category items.

**Attention Ability and Habitual Responding**

Finally, the relationship between attention capacity or ability (TAS scores) and habitual responding on the categorization task was examined in correlational analyses. Table 9 shows that collapsing across attention groups (all columns), increasing TAS scores were associated with less typical responses in three out of four experimental conditions (frequency of the first item generated in the typical and atypical conditions and the average frequency of the items generated in the atypical condition). Thus, a capacity for absorption is related to atypical responding regardless of the attention strategy employed by the participant.

**DISCUSSION**

Meditation led to a reduction in habitual responding. When participants were asked to respond atypically, the meditation group was able to provide the most atypical responses. This effect was not mediated by attention ability or tendency (as shown by the analysis of covariance with TAS as a covariate.) At the same time, when participants were asked to respond typically, there was no performance difference between groups. Thus, it appears that meditation leads to a reduction in habitual responding when non-habitual responses are optimal for the situation.

In addition, there is a relationship between absorption and cognitive performance on the category generation task. Regardless of the directions given to a participant, if a participant's TAS score is high, he or she will have a tendency to generate an atypical first response. In addition, when the directions are to respond atypically, the average frequency of the participant's responses are related to TAS scores. Again, a high TAS score corresponds to more atypical responses (lower category scores). In sum, these findings demonstrate that meditation does not result in overall atypical responding; however, it appears to increase atypical responding when participants are asked to respond atypically.

**TABLE 8 Category Production Frequency Across Attention Condition at Post-test in Study 2**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Meditation</th>
<th>Cognitive Control</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Frequency</td>
<td>292.08 (35.8)</td>
<td>299 (30.69)</td>
<td>294.96 (39.7)</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>153.17 (14.21)</td>
<td>159.13 (17.01)</td>
<td>158.04 (18.34)</td>
</tr>
<tr>
<td><strong>Atypical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Frequency</td>
<td>36.66 (21.7)</td>
<td>43.3 (23.11)</td>
<td>49.45 (27.47)</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>72.74 (16.68)</td>
<td>83.03 (13.36)</td>
<td>79.74 (15.16)</td>
</tr>
</tbody>
</table>

Note: A high number denotes a more typical or habitual response

**TABLE 9 Correlations (r) Between TAS and Cognitive Dependent Variables in Study 2**

<table>
<thead>
<tr>
<th>Cognitive Task</th>
<th>Meditation</th>
<th>Cognitive Control</th>
<th>Rest</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Frequency</td>
<td>-.14</td>
<td>-.42*</td>
<td>-.27</td>
<td>-.29*</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>-.14</td>
<td>-.32</td>
<td>.03</td>
<td>-.19</td>
</tr>
<tr>
<td>Atypical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Frequency</td>
<td>-.315</td>
<td>-.149</td>
<td>-.152</td>
<td>-.232*</td>
</tr>
<tr>
<td>Average Frequency</td>
<td>-.11</td>
<td>-.35</td>
<td>-.14</td>
<td>-.26*</td>
</tr>
</tbody>
</table>

*P < .05, +P < .01
not lead to a simple increase in atypical or non-habitual behavior but does influence one's ability to produce atypical responses under conditions where those responses are desirable.

GENERAL DISCUSSION

These studies show that engaging in meditation leads to a reduction in habitual responding. In sum, this was seen as a reduction, as compared to controls, in Stroop Interference in Study 1. This effect remained when arousal (APD) was used as a covariate. Thus, the reduction in habitual responding that was seen cannot be accounted for by a reduction in physiological arousal. A reduction in habitual responding was also shown in Study 2 through the production of less typical category exemplars (on average) by meditation participants when they were instructed to respond atypically. This effect remained when TAS was factored out. Thus, the reduction in habitual responding was not due to an inherent attention ability or tendency. Most importantly, this investigation shows that traditional accounts of the cognitive consequences of meditation can be demonstrated in experimental studies with randomly assigned participants, a secular form of meditation, and a short period of meditation.

The results of this investigation further suggest that the benefits of this attention strategy can be controlled. Meditation does not result in the mandatory production of atypical responding. Study 2 incorporated specific directions for participants to produce typical and atypical exemplars. When typical exemplars were expected, there was no difference in participants' performance across attention groups. In contrast, when atypical responding was requested, participants in the meditation group were able to provide more atypical productions on average. Thus, engaging in meditation does not inhibit the participant from engaging in more habitual responding (participants can generate typical category instances when requested). At the same time, it does allow the participant to generate more atypical (less habitual) responses when requested.

This investigation provides support for the idea of deautomatization and provides support for some of the claims in previous TM research. These findings agree with Deikman's original ideas and suggest that meditation may result in honing the general skill of refocusing attention on actions and cognitions that were previously habitual. It is likely that when this skill is used, the alteration of attention leads to the more flexible use of information through the encoding or retrieval of information not typically used in that situation. This renewed information availability supports less habitual responding by increasing the number of response alternatives, thereby reducing the prominence of a habitual response.

The concept of deautomatization does not conflict with recent models of automatic processing. Schneider and Logan describe the transition from controlled to automatic processing as a change from the use of algorithmic-based processing to memory-based processing. Both memory-based accounts of automaticity allow for deautomatization through the manipulation of input cues. If an individual reinvests attention into an action, the relevant information that is encoded may change. It follows that memory retrieval processes would be altered, and there would be the possibility of an interruption of the previously automatic behavior.

Anderson also described automaticity as a gradual change in underlying processing. Within his mathematical model of skill acquisition (Adaptive Control of Thought [ACT*]) automaticity was described as knowledge compilation. Specifically, practice with a particular series of declarative instructions or events results in performance based on a single step (a production rule), wherein retrieval of the original series was no longer necessary. Although no direct experimental evidence was provided, Anderson proposed that automatization within ACT* could be interrupted by two factors (or a combination of the two): 1) the strength of production rules other than the one of interest matching in declarative elements, and 2) the degree to which those rules overlap. Within this framework, it is possible that reinvesting attention in an automatic behavior might activate a number of overlapping (or highly similar) production rules (due to the manipulation of input cues) that would serve to interrupt the original automatic behavior. In general, deautomatization due to attention deployment is plausible within models of automaticity. Although the details are yet to be experimentally realized, in general, the process of deautomatization may involve the inhibition of automatic processes associated with the object of conscious attention, or the lack of retrieval of information underlying the automatic process due to the manipulation of input cues or retrieval of additional response alternatives based on newly encoded information.

Meditation, Arousal, and Habitual Performance

Previous research indicated that meditation led to a reduction in arousal. The findings of this investigation corroborate that result. In both tasks of Study 1, the meditation group produced a larger reduction in arousal than the control groups. However, this study determined that the cognitive performance of meditators was not mediated by the reduction in arousal. Analysis of the linear relationship between arousal and performance in the cognitive tasks of Study 1 revealed no consistent effects. If anything, lower arousal levels appeared to be related to more habitual responding. From these data, there does not appear to be a simple relationship between arousal and habitual performance. The best support for the conclusion that the cognitive effects were not attributable to arousal comes from incorporating APD as a covariate in all of the analyses of Study 1.

CONCLUSION

Until now, many clinical applications of meditation have assumed that meditation affects cognition; specifically, that meditation can help interrupt or change over-learned patterns of thinking and response. These clinical applications based
their assumptions on traditional religious writings or on research incorporating a form of meditation developed within a religious or spiritual tradition, which entails subject-selection problems. The main significance of this research is that it supports the assumptions made by clinical researchers that meditation can disrupt habitual patterns of behavior. At the same time, this research is not limited by the typical methodological problems associated with religious or traditional forms of meditation.

Moreover, meditation does not destroy the practitioner's ability to respond habitually. An individual has habits because more often than not, they serve him or her. Many times, the optimal response is the habitual one. If a car makes a sudden stop on the highway, the careful driver will habitually slam on the brakes. This is not a habit we would want to lose. At other times, it is more optimal to have a choice of behavior, to not be limited by past behaviors—for example, replacing a behavior such as yelling at one's child out of anger or frustration with a new response. This research supports the idea that meditation gives an individual the flexibility to respond in a non-habitual way, if non-habitual responding is what is optimal for the situation.

The results of this investigation support the hypothesis put forth by Deikman in the 1960s and suggest that meditation practice leads to the deautomatization of response. One result warranting further investigation is that TAS scores are related to atypical or non-habitual cognitive performance. In the past, TAS scores on the have been related to hypnotizability and the personality characteristic of openness to experience. In addition, a cross-sectional study revealed that TAS increased with increasing meditation practice. In the future, it would be interesting to see if the relationship between TAS scores and this cognitive capacity to respond in a non-habitual way is related to atypical or atypical fashion carries over to other cognitive tasks, is volitional (occurs only when requested), and is subject to training (ideally shown through the use of a longitudinal experimental design).

In this investigation, deautomatization was found immediately after engaging in meditation practice. Presumably, these effects are sustained over time and may become pronounced with longer practice. Future investigations ought to incorporate longer meditation training and other types of meditation training. To examine this proposal, for example, directions for Buddhistvipassana meditation include reinvesting every action or thought with attention and purposely attempting to dishabituate stereotyped patterns of perception and cognition. It may be that this type of meditation produces a greater amount of deautomatization. Given the recent upsurge of spiritual practice and concerns around the globe, understanding meditation in psychological terms will prove to be a valuable contribution to cognitive psychology.

APPENDIX A

Transcript of 20-minute Concentrative Focus on Breathing
Voice of Instructor Beth Roth, MSN, Yale School of Nursing

Coming now to a comfortable sitting position in a chair with your spine erect but not strained, maintaining a thought of your spine and your torso coming up out of the hip joints all the way through your neck and your head, and your head, being light and floating gently at the top of your spine. Take a moment now to locate the place in your body where you can feel your own breathing the most clearly and the most easily. This might be your nostrils, where you notice the air passing in and out or perhaps your chest that rises and falls slightly with your inhalation and your exhalation. Or maybe your belly, your lower abdomen, where there are slight movements with the rhythm of your breathing. Wherever it might be, bringing your attention now to this place and noticing your in-breath and your out-breath.

Without trying to change your breathing in any way, or to manipulate your breathing, or control your breathing, but rather just observing your own breathing. Befriending your breathing, bringing your awareness right up close to your breath and following the in-breath from its beginning to its end and following the out-breath from beginning to end. Bringing your full attention to your breathing, knowing that your breath is an anchor to the present moment, a way for you to be in touch with your experience in the present, moment by moment. Noticing the in-breath and the out-breath, as one follows the next. Following the in-breath for the entire length of its duration and following the out-breath for the entire length of its duration. Perhaps even noticing a slight pause at the end of the exhalation, just before your body starts to breathe in its next breath. And staying in touch, in this way, that is, your breath, moment by moment.

You may notice from time to time that your mind is wandering, that you are no longer with your breathing, but that your mind is lost in thought. Understanding when this happens that it is the nature of the mind to wander. It's the habit of the mind to look for distractions. And without criticizing yourself or your mind, without judgment, when you notice that your mind is wandering, simply note—it's the wandering mind—and then gently and with great care, invite your mind to return to your next breath. Bringing your awareness and your full attention to the next breath, and continuing to follow your breathing. Each time that you notice that your mind is wandering, there is no need to get caught up in the content of the thoughts, in the plot or the story line. Simply notice that you are thinking, that you are no longer with your breath, and very gently, escort your awareness and your full attention back to your breathing.

Letting go of any thoughts of how long you have been sitting here or how many minutes might be left in this sitting. But just simply staying with your breathing, approaching the next breath with fresh interest and new awareness, as if it were the first breath of this sitting. Each in-breath truly a new beginning, each out-breath another opportunity for a new beginning. Re-thinking and noticing your in-breath and your out-breath, one breath after the next, from moment to moment.
APPENDIX B

Memory Strategy

For the next 20 minutes, I want you to attempt to learn the list of 21 names below in the order in which they appear. In order to do this, I want you to use a mnemonic—or memory strategy—called the method of loci. The method requires that you visualize walking around an area with distinctive landmarks that you know well, and link the landmarks to the items to be remembered. That way, when you attempt to remember the list later, you can mentally inspect each location and the item that was placed there in imagination. For example, if the list consisted of fruit (apple, orange, banana, etc) and the location you were using to help you remember the items was the Yale campus, you might imagine giving an apple to your teacher in Sheffield Sterling Strathcona hall walking over to Woolsey hall and seeing a vendor selling oranges in the rotunda, and then you might imagine walking toward cross campus and noticing that a sculpture had banana peels hanging from it and so on. Later, it would be easy for you to follow the path and remember the items—apple, orange, and banana in order.

During the next 20 minutes, I want you to use the method of loci to remember the following list of 21 names, in order, using your dorm or the place you lived as you grew up as the location to be visualized. Do you have any questions?

1. Abraham Pierson
2. Samuel Andrew
3. Timothy Cutler
4. Elisha Williams
5. Thomas Clap
6. Naphtali Daggett
7. Ezra Stiles
8. Timothy Dwight
9. Jeremiah Day
10. Theodore Dwight Woolsey
11. Noah Porter
12. Timothy Dwight
13. Arthur T. Hadley
14. James R. Angell
15. Charles Seymour
16. A. Whitney Griswold
17. Kingman Brewster, Jr.
18. Hannah Gray
19. A. Bartlett Giamatti
21. Richard C. Levin

APPENDIX C

Stem Completion Stimuli:

<table>
<thead>
<tr>
<th>SET A</th>
<th>SET B</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABO</td>
<td>FLO</td>
</tr>
<tr>
<td>AFF</td>
<td>DEP</td>
</tr>
<tr>
<td>TEN</td>
<td>BRI</td>
</tr>
<tr>
<td>SCO</td>
<td>LA</td>
</tr>
<tr>
<td>MAR</td>
<td>DRA</td>
</tr>
<tr>
<td>EXP</td>
<td>GRO</td>
</tr>
<tr>
<td>THR</td>
<td>FIL</td>
</tr>
<tr>
<td>SHO</td>
<td>FRA</td>
</tr>
<tr>
<td>GAR</td>
<td>GEN</td>
</tr>
<tr>
<td>SPI</td>
<td>WEA</td>
</tr>
</tbody>
</table>

Category Production Stimuli:

<table>
<thead>
<tr>
<th>SET A</th>
<th>SET B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Precious Stone</td>
<td>A Unit of Distance</td>
</tr>
<tr>
<td>A Metal</td>
<td>A Unit of Time</td>
</tr>
<tr>
<td>A Color</td>
<td>A Snake</td>
</tr>
<tr>
<td>An Alcoholic Beverage</td>
<td>A Vegetable</td>
</tr>
<tr>
<td>A Fruit</td>
<td>A Flower</td>
</tr>
<tr>
<td>A Type of Music</td>
<td>An Article of Furniture</td>
</tr>
<tr>
<td>A Tree</td>
<td>A Sport</td>
</tr>
<tr>
<td>A Part of a Building</td>
<td>A Four-Footed Animal</td>
</tr>
<tr>
<td>An Occupation or Profession</td>
<td>A Part of the Human Body</td>
</tr>
<tr>
<td>A Bird</td>
<td>A Fish</td>
</tr>
</tbody>
</table>

APPENDIX D

Category Production Directions

In this part of the experiment, you will have 30 seconds to work on each page of this booklet. On each page is the name or description of a category. During the 30 seconds, I want you to write down on the page as many items included in that category as you can, in whatever order they happen to occur to you. For example, if you were given the category seafood you might respond with such items as lobster, shrimp, clam and so on. The words are to be written in the slots on each page for each category. When you hear the computer beep, you are to stop writing and turn over immediately to the next page of the notebook. You will then be given 30 seconds to write the names of as many members of that category as you can think of. This procedure will be continued through a total of 10 categories.

Stem Completion Directions

The following pages list 10 word beginnings and 6 spaces next to each. Please complete each word beginning to form English words; write six different completions for each beginning. Write the first completion in the space with number 1, the second completion in the space with number 2, etc. Do not write any proper names as completions. The goal is to come up with 6 different words. Words are not counted as different if they are the present and past tense of a word, a noun in its singular and plural forms, or a noun in various compound forms (applepie, applejuice). Please write words even if you are not sure of the exact spelling.
Questions Used in the Cognitive Control Condition of Study 3

What is the largest planet in the solar system?

What is the name of the first artificial satellite put in orbit by Russia?

What is the last name of the first person to set foot on the moon?

What was the last name of the ventriloquist who provided the voice for Charlie McCarthy?

What is the last name of the author of The Agony and the Ecstasy?

What is the last name of the villainous captain in the story Peter Pan?

What is the name of the legendary one-eyed giant in Greek mythology?

What is the last name of the author of the James Bond novels?

What kind of poison did Socrates take at his execution?

What is the name of the city in Italy that is known for its canals?

What is the palace that was built in France by King Louis XIV?

What is the capital of Chile?

What was the last name of the criminal killed by FBI agents outside a Safeway?

What is the name of an illegal move in baseball that results in all runners passing a base?

What was the name of the woman who assassinated President John Kennedy?

What is the last name of the author of The Stranger?

What was the last name of the actor in the role of Perry Mason on TV?

What was the last name of the female star of the movie As Good as It Gets?

In what year was Sigmund Freud born?

What is the name of an inability to sleep?

What is the name of the rubber object that is hit back and forth by hockey players?

What is the name of the singer who recorded What's Going On?

What is the term for hitting a volleyball down hard into the opponent's court?

What is the name of the spearlike object that is thrown during a track meet?

What are the people who make traps called?

What is the name of the poet who originally wrote The Divine Comedy?

In which city is Heathrow airport located?

What is the last name of the poet who wrote The Rubaiyat of Omar Khayyam?

What is the last name of the artist who painted Guernica?

What is the name of the nurse who was most responsible for photographing the US civil war?

What is the last name of the actor known as the Man with a Thousand Faces?

What is the last name of the clown on the Don't Look Back show?

What is the last name of the man who was most responsible for plowing up the Wind?

What is the last name of the signer who recorded Ain't No Mountain High Enough?

What is the term for hitting a volleyball down hard into the opponent's court?

What is the term in golf referring to a score of one under par on a particular hole?

In which sport is associated with Wimbledon?

What is the last name of the boxer who was known as the Manassa Mauler?

What is the last name of the author of the book 1984?

What is the last name of the composer of the Maple Leaf Rag?

What is the last name of the author of Our Town?

What is the last name of the author of the book 1984?

Which sport is associated with Wimbledon?

What is the last name of the author who wrote Brothers Karamazov?

What is the name of the process by which plants make their food?

What is the name of the rubber roller on a typewriter?

What is the last name of the composer of the Maple Leaf Rag?

What is the name of the navigation instrument used at sea to plot position by the stars?

What is the last name of the poet who originally wrote Don Juan?

What is the last name of the man who made the first artificial satellite orbit Russia?

What is the name of the author who wrote Gone with the Wind?

What is the last name of the author who wrote The Old Man and the Sea?

What is the last name of the man who was the radio broadcaster for the War of the Worlds?

What is the last name of the man who wrote The War of the Worlds?

What is the last name of the man who wrote The Star-Spangled Banner?

What is the last name of the playwright who wrote A Streetcar Named Desire?

What is the last name of the author who wrote Romeo and Juliet?

What is the name of the chapel whose ceiling was painted by Michelangelo?

What was the last name of the man who wrote The Canterbury Tales?

What was the last name of the author who wrote the Sherlock Holmes stories?

What is the name of the project, which developed the atomic bomb during World War II?

What was the last name of the French author who wrote The Stranger?

What was the last name of the European author who wrote The Trial?

In what European city is the Pantheon located?

What is the unit of electrical power that refers to a current of one ampere at one volt?

What is the last name of the man who proposed the theory of relativity?

In which city is the US Naval Academy located?

What is the name of the brightest star in the sky excluding the sun?

What is the name of the North Star?

What is the name of the Chinese religion founded by Lao Tse?

What is the last name of Buffalo Bill?

What is the last name of the mythical giant lumberjack?

What is the last name of the woman who supposedly designed and sewed the first American flag?

What is the last name of the author of Our Town?

What is the last name of the author of the book 1984?

What is the last name of the actress who received the Best Actress Award for the movie Mary Poppins?

Which sport is associated with Wimbledon?

What is the last name of the author who wrote Brothers Karamazov?

What is the name of the process by which plants make their food?

What is the name of the rubber roller on a typewriter?

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