Impact of a Dietary Change on Emotional Distress

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A single-subject design was used to investigate the impact of a dietary change on the emotional state of four individuals selected by means of the Behavioral Index of Metabolic Imbalance and a subsequent interview. The dietary change for three subjects consisted of a high protein–low carbohydrate diet void of sucrose and caffeine, whereas only caffeine and sucrose were eliminated for the fourth subject. The dependent variable used with the first subject was a self-report of symptoms experienced, whereas the Minnesota Multiphasic Personality Inventory (MMPI) and the Profile of Mood State (POMS) were used with the other subjects. Results revealed that subjects reported many symptoms and/or presented a distressed profile during baseline assessment. However, following a 2-week dietary change symptoms declined, and the MMPI or POMS profiles reflected a more stable and less distressed individual. Overall, the results suggest that a dietary change can remediate the emotional distress exhibited by some individuals.

During the past decade the public has become increasingly aware that diet can have an impact on behavior. This awareness has arisen primarily through the publication of books (e.g., Feingold, 1972) that have hypothesized an association between behaviors such as hyperactivity and dietary elements such as food colors and preservatives. Although such associations have generally not been substantiated (Conners, 1980), additional evidence, which seems to support a possible diet–behavior relationship, has increasingly appeared in the literature. Kwok (1968) described the adverse behavioral effects, for example, headache and nausea, that can occur from the ingestion of monosodium L-glutamate. Green (1969), Powers (1973), and Von Hilsheimer (1974) reported case studies of children whose behavioral disturbances, irritability, hyperactivity, and short attention span improved following a dietary change consisting of a high-protein/low-carbohydrate diet and the inclusion of various vitamin supplements. Mikkelsen (1978), Greden (1974), and others have reported that paranoid delusions, headaches, anxiety symptoms, depression, and insomnia have been eliminated or dramatically reduced following the elimination of or a reduction in the amount of caffeine consumed.

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Such case study observations are supported by a number of correlational studies. Prinz, Roberts, and Hantman (1980), for example, found that a significant relationship existed between consumption of carbohydrates and destructive–aggressive and restless behaviors in hyperactive children. Lester, Thatcher, and Monroe-Lord (1982) revealed that refined carbohydrate intake was negatively correlated with the intelligence and school achievement scores of 5- to 16-year-old children. Winstead (1976) and Greden, Fontaine, Lubetsky, and Chamberlain (1978) found that caffeine consumption was related to anxiety and depression in adult psychiatric patients. There are also a few experimental studies that relate various foods to psychological distress. King (1981), for example, using a double-blind design, found that allergic subjects reported significantly more cognitive–emotional, somatic, and mixed (headache, fatigue, and other aches and pains) symptoms when given the food extracts to which they were allergic than when given a placebo.

This summary of the literature seems to suggest that food can indeed produce a variety of maladaptive symptoms, at least in some individuals. However, most of the evidence consists of uncontrolled case studies and/or correlational studies. Few experimental studies, excluding those involving hyperactivity (Conners, 1980), have investigated the behavioral/emotional changes accompanying a dietary change.
To investigate the influence of diet on behavior, two elements must be identified: the dietary substances that seem to represent the offending substance and the individuals who are susceptible to these offending substances. The literature (e.g., Green, 1969; Greden, 1974) has repeatedly implicated refined carbohydrates, especially sucrose, and caffeine as offending substances for a subsample of the population and has advocated the benefits of a high-protein/low-carbohydrate diet void of sucrose and caffeine. Consequently, such a diet appears to be a logical candidate for investigation in a dietary change experiment. However, there are few guidelines regarding the identity of individuals who may be susceptible to such substances.

In an attempt to develop a means for identifying individuals who might profit from a dietary change, a symptom checklist was developed from a scale that initially consisted of the symptoms reported by individuals with hypoglycemia. Prior research had revealed that individuals expressing such symptoms were seldom diagnosed as hypoglycemic, but they frequently reported beneficial effects following adherence to a diet high in protein and low in carbohydrate with total elimination of caffeine and sucrose. A pilot study was conducted using this symptom checklist with introductory psychology students. Those reporting many of these symptoms were instructed to consume, for 2 weeks, a high-protein/low-carbohydrate diet that totally excluded sucrose and caffeine. Subjects were also told to exclude alcoholic beverages because they contain significant amounts of sucrose. During this 2-week period, subjects were also instructed to record the symptoms they experienced during the day. Those subjects who demonstrated a progressively decreasing record of symptoms and who reported a beneficial impact of the dietary change were subjected to an intensive interview regarding the exact nature of the symptoms they possessed. Approximately 20 such individuals were interviewed over the course of a 2-year period. These 20 individuals' descriptions of their symptoms were converted to a series of descriptive statements, and these statements represented the items of the Behavioral Index of Metabolic Imbalance (BIMI). Consequently, this pilot work resulted in the development of an instrument that may have potential for identifying individuals in need of a dietary change and suggested that there is a subsample of individuals in whom emotional and/or behavioral disorders are related to dietary factors.

The purpose of the present study was to investigate, in a series of single-subject experiments, the impact of a dietary manipulation on a person's emotional state. A secondary purpose was to attempt to identify the dietary elements that may contribute to the development of emotional distress.

Experiment 1

Method

Subject. M.W., a 24-year-old female graduate student, was selected for the experiment based on her response to the BIMI and a subsequent interview regarding each of the items that she endorsed on this instrument. The interview serves as a check on subjects' responses to the BIMI by providing information as to whether symptoms that are reported as occurring for no particular reason may be due to events in the subject's life. The subject participated in the study voluntarily, read and signed an informed consent after all questions regarding the experiment had been explained, and was debriefed regarding the outcome of the experiment.

Materials

The BIMI consists of a description of 72 cognitive (e.g., mental confusion, depression), behavioral (e.g., moody, aggressive), and somatic (e.g., sweating unexpectedly, indigestion) symptoms expressed by individuals who might profit from a dietary change (see Table 1). Respondents evaluate the frequency of occurrence of each symptom on a 5-point scale (1 = not at all and 5 = every day) and the severity of occurrence of each symptom. The severity of occurrence is assessed on a 4-point scale ranging from very mild (1) to extreme (4). The test–retest reliability, based on retesting 80 introductory psychology students 2-weeks later, is .81 for the frequency index and .90 for the severity index. To be selected by the BIMI, a potential subject must score 170 or higher on the frequency scale and 100 or higher on the severity scale. This cutoff score was selected after pilot studies indicated that individuals attaining lower scores did not report a beneficial impact of a dietary intervention.

In addition to the BIMI, a symptom checklist scale consisting of a listing of the symptoms, for example, fatigue, or sweating unexpectedly, assessed by the BIMI was constructed for use as a dependent variable measure to assist

1 A copy of this instrument can be obtained from the first author.

2 The evaluation of the severity of occurrence was included after M.W. took the BIMI.
Table 1
Items Representative of the BIMI

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>After getting a good night’s sleep (7 to 10 hr per night) for several nights in a row you still feel tired like you need more sleep.</td>
</tr>
<tr>
<td>7</td>
<td>You can be relaxed and sitting in a comfortable air conditioned room and start sweating unexpectedly.</td>
</tr>
<tr>
<td>17</td>
<td>You experience mental confusion. It seems as though many things are going on in your head and you can’t separate them out or make them clear.</td>
</tr>
<tr>
<td>30</td>
<td>You are moody.</td>
</tr>
<tr>
<td>49</td>
<td>You are too aggressive.</td>
</tr>
<tr>
<td>54</td>
<td>You are bothered with nausea and do not know what is causing it.</td>
</tr>
<tr>
<td>72</td>
<td>Just about anything makes you cry.</td>
</tr>
</tbody>
</table>

Note. BIMI = Behavioral Index of Metabolic Imbalance.

M.W.’s identification of and self-report of the symptoms she experienced each day.

Design and procedure. An A-B-A-B single-subject design was used to assess the impact of a dietary change on M.W.’s self-report of the symptoms she was experiencing. Immediately following the interview concerning the BIMI items, M.W. was instructed to record on the checklist (prior to retiring each evening) the symptoms she experienced and food she consumed during the day. This baseline record was collected for 19 days. In the treatment condition, M.W. was instructed to consume a high-protein/low-carbohydrate diet void of sucrose, caffeine, and alcohol for 2 weeks. This dietary plan also included a protein snack between meals and prior to retiring because some subjects reported that it is necessary to control for the recurrence of symptoms between meals. During this period she was told to continue recording, each evening, her symptoms and the foods she had eaten during the day. Following this 2-week treatment period, M.W. was instructed to revert to her baseline diet for 2 weeks and, following this reversal, the dietary change was reinstated for 2 weeks.

Results

M.W.’s baseline diet record revealed that she consumed many items containing sucrose and caffeine (tea, colas, and coffee, etc.). The treatment records revealed that these substances were totally eliminated from her diet. Figure 1 depicts the frequency of daily symptoms reported by M.W. during baseline and dietary intervention. Symptom frequency declined to zero during each dietary intervention phase, whereas reintroduction of baseline conditions produced both an immediate and a gradual increase in the number of reported symptoms. A time series analysis, the autoregressive integrated moving average model (Cook & Campbell, 1979; Glass, Willson, & Gottman, 1975), confirmed the visual interpretation of the data. Each of the three interruption parameters was significant ($p < .05$), or a significant change in the level of the time series occurred with each of the changes in the phases of the A-B-A-B design.

Discussion

The results of Experiment 1 reveal that the frequency of reported symptoms was altered quite dramatically with the introduction of a high-protein/low-carbohydrate diet, which suggested that the emotional and behavioral symptoms experienced by M.W. may be related to dietary factors. It is possible that the beneficial effect of the dietary intervention was due to the fact that M.W. was hypoglycemic; such individuals not only experience symptoms such as M.W.’s but also are treated with a high-protein/low-carbohydrate diet. This possibility was ruled out by a 5-hr oral glucose tolerance test.

It is also possible that the effect observed following the dietary change was due to expectancy. In view of the impossibility of disguising the dietary change, M.W. may have expected her symptoms to change as she moved from the baseline to the dietary intervention phase. Because the dependent variable consisted of M.W.’s self-report, it would seem to be maximally susceptible to the influence of such expectations. To minimize the existence
of such effects, a second experiment was conducted that used standardized psychological assessment measures as the dependent variable and a challenge phase in an attempt to convince the subject that the offending substances had been identified. Following the completion of the challenge phase, the subject was given a bogus report stating that certain foods had been identified as the cause of the symptoms and that these foods were to be avoided to prevent a return of symptoms. The subject was then told to add sucrose- and caffeine-containing substances back to her diet, because these substances did not seem to have an adverse effect. This procedure was instituted to create the expectation of remaining symptom free. Then, if the symptoms returned, evidence, unconfounded by expectations, would exist supporting the notion that sucrose and caffeine are the causal agents.

Experiment 2

Method

Subject. C.C., a 21-year-old female undergraduate student, was recruited based on her scores on the BIMI (score: 174 for the frequency scale and 132 for the severity scale) obtained during pretesting of several introductory psychology classes. After a subsequent interview concerning her responses to the BIMI items, C.C. was asked to participate in a study investigating the relationship between diet and behavior.

Materials. The Profile of Mood State (POMS; McNair, Lorr, & Droppleman, 1981) is a 65-item five-point adjective rating scale developed by means of a repeated factor analysis. This scale was included as a measure of the impact of the dietary change, because it measures six mood factors representative of the types of symptoms expressed by subjects selected by the BIMI. These mood factors consist of tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. In addition, the Minnesota Multiphasic Personality Inventory (MMPI), Form R (Hathaway & McKinley, 1967) was used as a dependent variable because it is sensitive to degree of emotional distress.

A Symptom Rating Scale was constructed to obtain subjects' self-report of the symptoms they experienced during the challenge phase of the study. This scale consisted of a list of 27 symptoms, such as exhaustion, light-headedness, and restless legs, evaluated on a 9-point scale ranging from not at all (1) to severe (9). An Expectancy Rating Scale was constructed to assess C.C.'s perceived benefit of the diet and her beliefs regarding the success of the challenge phase in identifying substances she was reacting to. This scale consisted of the following four questions: (a) Do you believe the diet you have been on has made you feel better? (b) Do you believe we identified the substances creating some of your symptoms? (c) Do you believe the substances we said were creating some of your symptoms were really creating them? (d) Do you believe that you can add the above-mentioned substances to your diet without making you feel bad (those you did not react to)? In addition to the above materials, the BIMI described in Experiment 1 was used.

Figure 1. Frequency of M.W.'s daily symptoms during baseline and intervention.
Design and procedure. An A-B-A-B single-subject design was used to assess the impact of the diet change on C.C.'s emotional state. The baseline condition in this design consisted of having C.C. consume her typical diet, which consisted of milk, fruit, eggs, or cereal for breakfast; salad, cheese, or eggs for lunch; a snack such as a soft drink, fruit, or something sweet between lunch and dinner; salads for dinner, ice cream, candy, or cookies between dinner and bedtime. The treatment condition consisted of a high-protein/low-carbohydrate diet void of sucrose, caffeine, and alcohol and included a protein snack between meals and prior to retiring. A challenge test was administered between the treatment phase and the reintroduction of the baseline phase to attempt to convince C.C. that the offending foods had been identified.

Immediately following the interview concerning C.C.'s responses to the BIMI items, she completed the MMPI and the POMS to attain baseline measures on these instruments. C.C. was then instructed to consume the treatment diet for 2 weeks. During this period C.C. was also instructed to record the food eaten each day. Following this 2-week dietary intervention, the MMPI and POMS were again administered to assess the impact of the dietary change. C.C. was then instructed to remain on the diet while the challenge phase of the study was implemented. C.C. was told that the challenge phase was designed to identify those foods that were producing her emotional symptoms and/or behavioral problems.

The challenge test consisted of challenging C.C. in a double-blind fashion with caffeine and sweeteners including saccharin, aspartame, sucrose, and fructose. These substances were implicated in the prior literature (e.g., Greden, 1974) and pilot studies as the primary culprits in the generation of emotional and/or behavioral disturbances. The double-blind challenge consisted of two phases. First, caffeine (one No-Doz tablet containing 100 mg of caffeine), saccharin (50 mg or the equivalent of 4 teaspoons of sugar), aspartame (0.95 mg, which is approximately equivalent in sweetness to 4 teaspoons of sucrose, because aspartame is 160 to 200 times as sweet as sucrose), and gelatin (the placebo) were placed in gelatin capsules. The capsules were placed in containers coded according to the order in which the experimenter was to administer them. A different randomly assigned substance was administered to C.C. on 4 consecutive days. C.C. was instructed to refrain from eating for 3 hr prior to the challenge. On each of the challenge days, C.C. was instructed to rate the severity of any symptoms she was experiencing on the Symptom Rating Scale at the beginning of each of three 5-min periods prior to taking the designated capsule to provide baseline data on the severity of symptoms experienced. After taking the designated capsule, C.C. rated the symptoms she experienced on the Symptom Rating Scale at 5-min intervals for the next 45 min.

To challenge C.C. with sucrose and fructose, a different procedure had to be employed because it was not feasible to ask her to take the number of capsules equivalent to 4 teaspoons of sucrose. As a consequence, sucrose (4 teaspoons), fructose (approximately 2.5 teaspoons because fructose is 1.5 times sweeter than sucrose), and aspartame (0.95 mg) were dissolved in 8 oz of water and administered double-blind to C.C. in the same fashion as the capsules. Ratings of symptoms experienced were assessed at 5-min intervals during the 15-min baseline period and the 45-min challenge period.

Following the challenge phase C.C. was told that, based on the results, she seemed to be reacting to saccharin and monosodium L-glutamate, a flavor enhancer found in many foods. As a consequence, she was asked, for the next 3 weeks, not to eat those foods but to add back to her diet the other substances such as sweets and caffeine-containing beverages she had been told to avoid because she had not reacted to these substances. In actuality the challenge test was totally uninformative. However, telling C.C. to avoid these supposedly offending foods should create the expectation that she could consume all other foods and remain symptom free. C.C. was then given the Expectancy Rating Scale. At the end of the 3-week period, C.C. was administered the MMPI and POMS once again to assess the impact of the reintroduction of sucrose and caffeine. C.C. then again returned to the dietary intervention for 2 weeks. At the end of this 2-week period, C.C. was administered the MMPI and POMS and debriefed regarding all aspects of the experiment. In particular, she was told that the challenge phase was uninformative but that her symptoms returned with the addition of sucrose and caffeine to her diet.

Results

C.C.'s diet record revealed that, during the treatment phase, she eliminated sucrose- and caffeine-containing beverages from her diet. This is in contrast to her self-report of her typical diet, which consisted of frequent consumption of sweets and diet soft drinks. C.C.'s response to the expectancy scale suggested that the challenge test benefited her (a rating of 9 on the 9-point scale) and that we had identified the foods creating her symptoms (a rating of 7). In addition, she indicated that she believed that the substance we stated as creating her symptoms was actually creating them (a rating of 7), and she felt she could add sucrose and caffeine back to her diet without any ill effects (a rating of 6). As a consequence, the results of the expectancy scale suggested that the challenge test was effective in convincing C.C. that we had not only identified the offending substances but that she could also add sweets, tea, and coffee back to her diet with no ill effects.

Figure 2 presents the results of the repeated assessment of the MMPI. From Figure 2, it can be seen that C.C. had elevated MMPI scores (T > 70) on Scales 2, 7, and 8 (depression, psychasthenia, and schizophrenia), which suggests that she was experiencing a distress syndrome consisting predominantly of

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3 Aspartame is the nonnutritive sweetener produced by and obtained from G. D. Searle.
depression, anxiety, and nervousness (Lachar, 1974). However, following a 2-week dietary change, these elevations declined considerably (all T scores < 60) and to such a degree that C.C. presented a profile of an individual experiencing little distress. Following a 3-week reintroduction of a typical diet including sucrose and caffeine her MMPI profile again began to present the picture of a distressed individual with Scale 2 elevated (T > 70) and the Scales 7 and 8 (psychasthenia and schizophrenia) approaching a T score of 70. These elevations once again declined when the dietary change was instituted. Similar trends were observed in the POMS data at each treatment phase. However, these changes are not presented because they were not statistically significant.

Because a single-subject design was used with a limited number of repeated measures for each subject, there is no suitable standard statistical test to assess differences in the scale scores for the various phases of the design. As an approximation to a statistical test, the following procedure was used. For each scale on which two scores were to be compared, the standard error of the difference between repeated testings was calculated from the standard error of measurement of the scale. The calculations were based on a standard deviation of 10 (because all scales were T scores with standard deviations of 10) and with the correlations between test and retest based on data reported in the literature for test–retest reliabilities over periods of approximately 1 to 3 weeks (Hathaway & McKinley, 1967; McNair et al., 1981). If differences between pairs of scores are normally distributed with a mean of zero, and a sampling error equal to the standard error used, it is appropriate to use the normal distribution to determine critical values for rejection of the null hypothesis at the .05 level. We hypothesized that scores would improve following dietary intervention and deteriorate following return to baseline. Therefore, we considered only one tail of the normal distribution and multiplied the standard error of the differences by 1.65 to obtain an apparent .05 level. Because the distribution of differences under the null hypothesis may depart from normal, this .05 level is only approximate, and in any event, it would apply only to a single test and not to the entire set of tests that were done. Therefore, the results of this test procedure should be regarded with caution.

This statistical procedure was used to identify the scales on which C.C. demonstrated a
significant change in test scores between adjacent phases of the A-B-A-B single-subject design. Five of the MMPI scale scores (Scales 2, 4, 7, 8, and 10) changed significantly ($p < .05$) as the treatment conditions changed. Because five of the MMPI scales changed significantly, it was concluded that we had correctly inferred, from the visual inspection, that the emotional status of C.C. changed with a change in the treatment conditions.

**Discussion**

The results revealed that C.C. experienced less psychological distress during the dietary intervention phase than during her baseline diet, which included sweeteners and caffeine. This improvement would seem to be due to the dietary intervention for two reasons. First, the significant improvement over baseline obtained following the first dietary intervention phase reversed or demonstrated a significant deterioration when the consumption of sucrose and caffeine was reinstated. Second, and of more importance, is the fact that the reversal took place in spite of the fact that the expectancy questionnaire indicated that the double-blind challenge had convinced C.C. that the offending dietary substances had been identified and that she could consume sucrose and caffeine with no ill effects. In fact, at a later point in time, she spontaneously admitted that she was elated with the results of the challenge test because it meant she could resume eating sweets.

However, it could still be argued that C.C.'s verbal response to the expectancy questionnaire could also be influenced by her expectations. Consequently, a third experiment was conducted to replicate the results of the second experiment and to determine if the challenge test was, for some reason, insensitive to the ingestion of caffeine and sucrose. If a reaction could not be attained from the challenge, one of two conclusions must be drawn. Either the beneficial effects of the dietary treatment noted on the MMPI are due entirely to some artifact, such as expectancies, or the procedure followed in the challenge test is in some way inappropriate. For example, it may be that the quantity of caffeine and/or sucrose was insufficient to produce a reaction or it was not administered for a sufficient length of time.

**Experiment 3**

**Method**

**Subject.** W.B., an 18-year-old male undergraduate student, was selected for the study in the same manner as C.C. was in Experiment 2.

**Materials.** The materials used in Experiment 3 were identical to those used in the preceding experiment.

**Design and Procedure.** The design and procedure for Experiment 3 were an exact replication of that used in Experiment 2, with the exception that an A-B-A design was used rather than the A-B-A-B design used in Experiment 2. Following baseline assessment on the MMPI and POMS, W.B. was administered the treatment diet for 2 weeks, assessed again on the MMPI and POMS and then challenged in the same manner as C.C. in Experiment 2. Following the double-blind challenge, W.B. was given a bogus report regarding the dietary substances he was sensitive to and told he could resume consuming caffeine and sucrose. W.B. was then asked to add sweets and caffeine back to his diet for 3 weeks but to avoid saccharin and monosodium L-glutamate. Following this 3-week period, he was reassessed on the MMPI and POMS, debriefed, and told that he seemed to be sensitive to sucrose and especially to caffeine.

**Results**

W.B.'s food record revealed that, during baseline, he consumed items such as about a gallon of tea a day, beer, pasta, chips, sandwiches, meat, and salads. During the treatment condition he eliminated all sucrose- and caffeine-containing beverages and alcohol from his diet.

Figure 3 presents the repeated assessment of the results of the MMPI. From Figure 3, it can be seen that W.B. had elevated scores ($T > 70$) on seven of the nine clinical scales, which strongly suggested that he was experiencing a great deal of emotional turmoil. Particularly high elevations occurred on Scales 7 and 8 (psychasthenia and schizophrenia), which suggested that W.B. was depressed, worried, tense, and nervous (Graham, 1977). However, following the 2-week dietary intervention, only Scales 7 and 8 remained elevated (above 70), but the degree of elevation had been reduced rather dramatically. This suggests that the amount of turmoil, depression, and tension he was experiencing had declined considerably. When W.B. resumed his consumption of sucrose and caffeine for a period of 3 weeks, his MMPI profile revealed elevations on six of the nine clinical scales. Once again, Scales 7 and 8 showed the greatest elevation, indicating a
Figure 3. W.B.’s Minnesota Multiphasic Personality Inventory (MMPI) profiles during baseline and after intervention. (See Figure 2 for MMPI scale abbreviations.)

A great deal of emotional turmoil. Figure 3 also suggests that W.B.’s MMPI profiles are “fake-bad” profiles, according to the F–K rule (Carson, 1969; Gough, 1950; and Meehl, 1951, whose work is cited in Graham, 1977). However, Graham (1977) suggested that F Scale T scores in the 65 to 79 range are more likely to indicate socially deviant convictions, moodiness, psychosis, or severe neurosis, rather than be indicative of an attempt to dissimulate. Even if W.B. was deliberately exaggerating his symptoms, he nevertheless demonstrated an improvement without any abatement of the “look-bad” profile, which suggested a genuine improvement with the dietary intervention. Similar trends demonstrating improvement following dietary intervention were observed in the POMS data. However, these changes are not presented because they were not statistically significant.

The criterion for assessing significance of change in scale scores presented in Experiment 2 was applied to W.B.’s data. This analysis revealed that 2 of the MMPI scales (Scales 7 and 8) changed significantly \((p < .05)\) as the adjacent phases of the treatment conditions changed. However, fewer of the MMPI scale scores reached significance when applying this statistical criterion than may have been concluded from a mere visual inspection.

W.B.’s ratings of the severity of symptoms experienced during each 5-min interval of the challenge phase were summed across the symptoms. Figure 4 depicts these total scores for each 5-min time interval. A descriptive analysis was used to interpret these data because the autocorrelation that exists between adjacent data points and the existence of relatively few data points preclude use of a time series analysis or analysis of variance (Cook & Campbell, 1979). From this figure it can be seen that the trend established during baseline was maintained for all foods except sucrose and caffeine. At 30 min following the sucrose challenge, W.B. reported an increase in exhaustion, headache, weakness, light-headedness, stomach-upset, and flightiness. In addition, W.B. volunteered that the substance he drank made him feel bad. When challenged with caffeine, approximately 30 min had to elapse before W.B. began experiencing an increase in number and severity of symptoms over and above that experienced during baseline. At 40-min postchallenge, the last predetermined assessment period, W.B. reported experiencing a moderately severe headache, and some degree of weakness, light-headedness, difficulty in concentration, nausea, detached, tightness in chest, flightiness, and a warm and dry mouth. When W.B. returned the following day he asked that he not be given the prior day’s substance because he felt progressively worse. Consequently, from the results of Figure 4 and W.B.’s spontaneous verbal
reports, it appears that sucrose and particularly caffeine may produce a variety of symptoms in him. It seems important to note that the change in symptoms during the saccharin challenge represented a decline, and this decline was manifested predominantly during the baseline phase.

Discussion

The results obtained from Experiment 3 support the results obtained from Experiment 2. The emotional turmoil experienced by W.B. at initial baseline declined following dietary intervention and then deteriorated when W.B. reverted to eating foods that included sucrose and caffeine. Once again this deterioration took place after W.B. had completed the double-blind challenge and received a bogus report that sucrose and caffeine could be added back with no ill effects because other substances had been identified as the offending substances.

The double-blind challenge also seems to provide evidence supporting the notion that W.B.’s emotional state was partially a function of his diet and that sucrose and caffeine are probably two offending substances. This indication seems to be supported by the fact that either no change or a decrease in self-report of symptoms followed the ingestion of saccharin, gelatin, fructose, and aspartame. However, the changes in the responses to the challenge could not be statistically analyzed, and thus these results should be interpreted cautiously.

Experiment 3 provided evidence suggesting that the challenge may be effective in identifying the offending dietary substances and that the offending substances in W.B.’s case may be caffeine and sucrose. However, several sources of evidence suggest that the challenge phase must be extended to more definitively isolate the offending substances. C.C.’s verbal reports revealed that her symptoms did not begin to return until she had ingested sucrose for several days. W.B.’s challenge data revealed that his

![Figure 4. W.B.'s ratings of symptom severity during baseline and challenge.](image-url)
response to caffeine had just begun when the challenge was terminated and that his response to sucrose was rather weak. As a consequence, a fourth experiment was conducted in which only sucrose and caffeine were totally eliminated from the diet, the length of the challenge was extended, and standardized psychometric tests were used as the challenge outcome measure as opposed to the Symptom Rating Scale used in Experiment 3.

Experiment 4

Method

Subject. D.S. was a 50-year-old housewife who responded to an advertisement in the local newspaper that requested volunteers for a study of the cause and treatment of fatigue and depression. She was selected for the study based on her response to the BIMI and a subsequent interview.

Materials. The MMPI, BIMI, and POMS were again used in the present study. In addition to these instruments the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and a Background Information Questionnaire were administered to D.S. The BDI is an inventory composed of 21 categories of symptoms and attitude descriptions of depression that are evaluated on a graded series of four to five self-evaluative statements. The Background Information Questionnaire was constructed to obtain information regarding presenting symptoms, medications, illness or disorders, type of treatment received, perception of the cause of the symptoms, belief regarding the influence of food on the way they feel, and a specification of the food that affects them and the type of effect it elicits.

Design and procedure. An A-B-A-B single-subject design was used to assess the impact of the dietary change on D.S.'s emotional state. D.S. first completed the Background Information Questionnaire, BDI, POMS, and MMPI. She was then requested to maintain a diet record for 3 consecutive days during the next week. Each diet record sheet requested the type of food or drink consumed, the approximate amount, and the time it was consumed.

After completing these diet records, D.S. was given six diet records to complete and a meal plan to follow for the next 2 weeks. This meal plan excluded all caffeine or caffeine-containing products as well as any sucrose or sucrose-containing products. After 2 weeks, she returned and was readministered the POMS, MMPI, and BDI and was given a second meal plan to follow for 2 weeks. This second meal plan was derived from her initial diet record and represented an attempt to reinstate the baseline diet as closely as possible. Two weeks later D.S. was again readministered the POMS, BDI, and MMPI.

D.S. was then requested to revert back to the dietary treatment meal plan for 2 weeks. Following this period she completed the POMS and BDI and was challenged double-blind with anhydrous caffeine (400 mg, or an amount equivalent to her daily intake, as reflected by the baseline diet records), placebo (lactose), saccharin (200 mg), sucrose (2 1/2 cups in a gallon of lemonade), and Equal, the artificial sweetener containing aspartame (an amount equivalent in sweetness to 2 cups of sucrose, placed in one gallon of lemonade).

To conduct the double-blind challenge the experimenter received three pill bottles, each containing four capsules and labeled A, B, or C and two one-gallon jugs of lemonade labeled either A or B. Each pill bottle contained four capsules, each filled with either 330 mg lactose, 100 mg caffeine, or 50 mg saccharin. The experimenter then received a slip of paper designating the order in which the pills or lemonade were to be administered. The order of administration of the challenge substances was saccharin, caffeine, sugar, Equal, and lactose. For each challenge substance, D.S. was administered the POMS and BDI prior to beginning the challenge and at 1 and 24 hr during the challenge. D.S. was instructed to space the consumption of the challenge substance (pills or lemonade) over the 24-hr time interval rather than consuming it all during one short time interval.

Following the 24-hr administration of the BDI and POMS, the assessment measures were scored immediately to ascertain if a significant deterioration in mood, using the procedure outlined in Experiment 2, occurred between the initial or prechallenge assessment and the 1- and 24-hr postchallenge assessment. A significant change was defined as a significant change between the initial and the 1- and 24-hr assessment or between the initial and 24-hr assessment. If a significant change was not detected between the initial and 24-hr assessment, the 24-hr assessment represented the baseline measure for the assessment of the next challenge substance. The rationale underlying this decision was that, if a significant change did not occur during the 24-hr challenge, the subject was probably not sensitive to the challenge substance. If a significant deterioration in mood did occur from baseline to the 24-hr assessment period, the next challenge substance was not administered until the reaction had subsided. This procedure had to be implemented following the sucrose challenge. A 24-hr time interval restored D.S. to baseline. During the actual challenge there were two deviations from this prescribed procedure. First, the 24-hr saccharin assessment was not used as the caffeine baseline because D.S. could not return the next day. Three days elapsed between the termination of the 24-hr saccharin challenge and the beginning of the caffeine challenge. Second, the caffeine 24-hr assessment was used as the sucrose baseline even though a significant improvement in mood existed during the caffeine challenge. The rationale underlying the use of this as the sucrose baseline was that the direction of the effect was opposite that which was expected, and the 24-hr caffeine assessment was similar to the saccharin baseline assessment.

Following the challenge phase, D.S. was debriefed and told that the challenge phase had indicated that she was sensitive to sucrose and that this substance should be eliminated from her diet if she wanted to remain symptom free.

Results

D.S.'s Background Information Questionnaire revealed that her primary presenting complaints were being tired, having trouble going to sleep and staying asleep, nerves,
headache, and “my bones even feel like they are boneless at times.” She reported having high blood pressure, which was controlled by medication, having been diagnosed as a borderline hypoglycemic, having symptoms of a hiatal hernia, and having neck trouble. Although she reported believing that food could affect the way one feels, the only food item she reported as affecting her was chocolate, and this item reportedly caused headaches.

D.S.’s baseline diet record revealed that she consumed approximately four cups of coffee and two diet cola beverages each day for a total of about 400 mg of caffeine a day (if it is assumed that each cup of coffee has 75 mg of caffeine and each diet cola beverage has about 50 mg of caffeine). The baseline diet record also revealed that D.S. consumed sucrose each day in the form of at least one pack or bar of candy and at least 1 oz of mixed candy in addition to the sucrose found in other foods such as sweet and sour pork. However, her consumption of sucrose did not seem to be excessive. During the dietary intervention the diet records revealed that D.S. totally eliminated caffeine and sucrose from her diet. However, she reintroduced them during the return to baseline.

D.S.’s diet records were then analyzed to determine the approximate number of calories consumed during the baseline and dietary intervention phases and the percentage of calories derived from protein, fat, and carbohydrates. This analysis was conducted to determine if D.S.’s dietary consumption pattern changed dramatically across the phases of the study. This assessment was accomplished by taking the amount of a given substance that was consumed, as estimated from the diet records, and converting that to calories and grams of fat, carbohydrates, and protein through the use of Pennington and Church’s (1980) food composition tables. The number of calories and grams of fat, carbohydrates, and protein were then summed for each day and averaged across assessment days for the baseline and dietary intervention phases. This analysis revealed that the average number of calories per day D.S. consumed during baseline was 2,415.33 and 1,955.2 during dietary intervention. This reveals that D.S. consumed slightly fewer calories during the dietary intervention. However, the difference did not exceed her daily fluctuation in caloric intake during baseline (range = 1,977–3,059 calories) or dietary intervention (range = 1,400–2,731).

Assessment of the contribution of fat, carbohydrates, and protein to D.S.’s calorie intake revealed that she received about the same percentage of calories from fat during baseline (55%) and dietary intervention (50%). Slightly fewer calories were derived from carbohydrates (35% vs. 42%), and more were derived from protein (17% vs. 9%) during dietary intervention than during baseline. However, this was expected because sucrose was restricted during dietary intervention, and the data suggest that this restriction was compensated for primarily by increasing protein intake. Thus, although D.S.’s dietary consumption pattern changed slightly from baseline to dietary intervention, it does not seem to be a dramatic change. Rather, it seems to be one that was forced on her as a result of the requirements of the experiment. In addition, her dietary consumption pattern does not seem to be out of line with the typical U.S. dietary intake patterns. Page and Friend (1978) revealed that carbohydrates contribute about 46% of the energy content of the national diet, fat contributes about 42%, and protein contributes about 11%–12%.

Table 2 presents the results of the repeated assessment of the POMS and BDI. The MMPI data are not included because the profile changed very little across treatment conditions. The POMS baseline scale scores in Table 2 reveal that D.S. presented a profile of an individual similar to that of the average psychiatric outpatient on whom the norms were developed. The one scale score that seems to deviate from this pattern is the fatigue scale. D.S. revealed that she had less energy and a greater sense of weariness than did the typical subject in the psychiatric normative sample. The baseline BDI score reveals that D.S. was moderately to severely depressed (Beck et al., 1961). Table 2 also reveals that all the POMS scale scores and the BDI score demonstrated an improvement (increased vigor scores reflect an improvement) following dietary intervention. D.S. no longer reported experiencing depression and reported feeling more energetic and sleeping better than she had in several years. This improvement deteriorated following a return to baseline to the point that D.S. was once
Table 2

<table>
<thead>
<tr>
<th>POMS factor</th>
<th>Baseline 1</th>
<th>Dietary intervention</th>
<th>Baseline 2</th>
<th>Dietary intervention</th>
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<tr>
<td>Tension-anxiety</td>
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<td>37</td>
<td>49</td>
<td>31</td>
</tr>
<tr>
<td>Depression-dejection</td>
<td>42</td>
<td>37</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td>Anger-hostility</td>
<td>47</td>
<td>43</td>
<td>57</td>
<td>39</td>
</tr>
<tr>
<td>Vigor**</td>
<td>48</td>
<td>66</td>
<td>46</td>
<td>67</td>
</tr>
<tr>
<td>Fatigue**</td>
<td>67</td>
<td>44</td>
<td>67</td>
<td>44</td>
</tr>
<tr>
<td>Confusion-bewilderment</td>
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<td>42</td>
<td>54</td>
<td>42</td>
</tr>
<tr>
<td>BDI** score</td>
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<td>5</td>
<td>24</td>
<td>7</td>
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</tbody>
</table>

Note. BDI = Beck Depression Inventory; POMS = Profile of Mood State.
* p < .06. ** p < .05.

again depressed, and had little energy. She also reported having to resume taking sleeping pills to fall asleep. When the statistical procedure outlined in Experiment 2 is applied to the POMS and BDI scale scores (using a standard deviation based on the combined scores of moderately depressed patients in two studies [Beck et al., 1961] and a mean test–retest reliability of .76 [Beck, Steer, & Garlin, 1983] for the BDI scores) only the vigor, fatigue, confusion-bewilderment and BDI scores changed significantly between adjacent phases. However, the lack of vigor and persistent fatigue represented the most significant presenting complaint of D.S., which suggested that the dietary change remediated D.S.’s most dominant symptoms.

Table 3 depicts the results of the challenge phase of this experiment. Using the statistical procedure outlined in Experiment 2, the caffeine challenge resulted in a significant improvement (p < .05) in vigor, fatigue, confu-

Table 3

<table>
<thead>
<tr>
<th>POMS factors</th>
<th>Saccharin</th>
<th>Caffeine</th>
<th>Sucrose</th>
<th>Equal</th>
<th>Lactose</th>
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<td>24 hr</td>
<td>Baseline</td>
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<td>Time</td>
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<td>32</td>
<td>29</td>
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<tr>
<td>Depression-dejection</td>
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<td>34</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
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<td>39</td>
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<td>37</td>
<td>37</td>
<td>37</td>
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<tr>
<td>Vigor**</td>
<td>73</td>
<td>67</td>
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<tr>
<td>Fatigue**</td>
<td>39</td>
<td>40</td>
<td>37</td>
<td>67</td>
<td>34</td>
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<tr>
<td>Confusion-bewilderment</td>
<td>37</td>
<td>67</td>
<td>37</td>
<td>36</td>
<td>33</td>
</tr>
<tr>
<td>BDI</td>
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<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. BDI = Beck Depression Inventory; POMS = Profile of Mood State.
* p < .06. ** p < .05.
sion-bewilderment, and the BDI scores \( p < .06 \). The sucrose challenge resulted in a significant deterioration \( p < .05 \) on the vigor, fatigue, and confusion-bewilderment scales of the POMS. The BDI score was significant at the .06 level.

Discussion

The results of Experiment 4 revealed that the 2-week dietary intervention resulted in a significant improvement in D.S.'s mood state and this mood state once again deteriorated following a reversal back to her baseline diet. The double-blind challenge seems to provide evidence that this improvement was due to the dietary change and not due to some other rival explanation such as expectancies because D.S.'s mood state deteriorated significantly only when challenged with sucrose. However, D.S.'s mood state also demonstrated a significant improvement following the caffeine challenge. Because the sucrose challenge followed the caffeine challenge, it is possible that the significant deterioration during the sucrose challenge represented a rebound to the withdrawal of the caffeine. If such a phenomenon actually existed the apparent sucrose effect would be an artifact of the caffeine withdrawal. There are several sources of evidence that suggest that such an artifactual effect was not produced. The baseline data for the caffeine challenge were, for the scales that significantly improved, elevated above which existed during all other challenges. This suggests that, for some reason, D.S.'s emotional state had deteriorated prior to the beginning of the caffeine challenge. Following the completion of all challenges, D.S. was questioned regarding the possible consumption of a forbidden food prior to the caffeine challenge. She stated that she and her husband had eaten at a restaurant the preceding night and some of the food may have contained sucrose. She also reported feeling worse following consumption of that meal. Therefore, it is possible that something in the prior evening's meal produced a deterioration in D.S.'s mood state, and the effect noticed during the caffeine challenge represented the fading away of that effect. It is also possible that the caffeine assisted in the remediation of that effect because it is a stimulant for some individuals and produces the effect of decreased fatigue and increased energy levels.

The second source of evidence suggesting that the sucrose challenge was not artifically produced by the caffeine withdrawal is that the sucrose baseline scores are similar to the baseline scores for all other challenge substances except caffeine. This suggests that D.S. began the sucrose challenge at her true baseline level. Finally, several weeks following the completion of the experiment, D.S. unexpectedly returned to express her appreciation for the benefit she had derived from the experiment. At that time she stated that she was doing very well as long as she remained off sucrose.

Such evidence suggests that the sucrose challenge reflects a true deterioration in mood state as a result of the sucrose ingestion. It would also seem to be important to note that the mood states that deteriorated when D.S. was challenged with sucrose corresponded exactly to the mood states that varied as the treatment conditions varied again strongly implicating sucrose as the offending substance. Consequently, when the double-blind challenge is coupled with the A-B-A-B design, a strong case seems to exist supporting the notion that D.S.'s mood disturbance was due to dietary factors and, in the case of D.S., that the offending substance appears to be sucrose.

General Discussion

The results of these experiments have consistently suggested that diet may have a significant influence on the emotional response of the selected subjects. Such a conclusion is reached when a record of symptoms experienced is maintained, when emotional stability is assessed by standardized assessment measures such as the MMPI and the POMS, and by the results of a double-blind challenge. Consequently, the present study seems to provide evidence supporting the case studies (e.g., Green, 1969) that contend that some psychological dysfunctions can be remediated by means of a dietary alteration. Although this may suggest that certain diagnostic categories may be responsive to dietary interventions, drawing such a conclusion would seem to be premature, because the study focused on the impact of the dietary intervention and did not attempt to devise a Diagnostic and Statistical
Manual of Mental Disorders, third edition (DSM-III) diagnosis of the subjects. In addition, the subjects in the present study were volunteers for an experiment and not clients seeking help for psychological problems. (D.S. had sought help from the medical profession for a variety of related problems such as being fatigued and unable to sleep.) It would be inappropriate to generalize these results to a population of subjects seeking help under more typical circumstances. Such a generalization is an empirical question.

We also want to point out that the results obtained from the last three experiments were not consistent. The dietary change resulted in a significant change in five MMPI scores for C.C. and two for W.B., whereas three POMS scores and the BDI changed significantly for D.S. Such differential responding could be due to the fact that idiosyncratic responses occur to dietary substances. Caffeine, for example, has been demonstrated to produce a variety of responses ranging from anxiety (Winstead, 1976) and depression (Sawyer, Julia, & Turin, 1982) to increased alertness and less fatigue (Rall, 1980). Also, the subjects in the present study may have been responding to different dietary substances. The double-blind challenges suggested that W.B. was responding primarily to caffeine, and D.S. was responding to sucrose. If the subjects were responding to different substances, different responses should be attained. It is known that excessive consumption of caffeine can result in nervousness, restlessness, and insomnia, presumably because of caffeine's central nervous system stimulant effects (Rall, 1980). In addition, caffeine increases the secretion of the catecholamines epinephrine and norepinephrine (Sawyer et al., 1982), and anxiety and other symptoms of caffeine ingestion are similar to those side effects produced by ingestion of these substances (Innes & Nickerson, 1975).

It has also been shown (Fernstrom & Wurtman, 1971) that a carbohydrate-rich diet such as one high in sucrose can cause an increase in plasma tryptophan, which in turn results in an increase in serotonin synthesis. Hartmann (1981) repeatedly demonstrated that administration of L-tryptophan not only increases the perception of sleepiness but also decreases sleep latency.

Clearly, the relationship between diet and psychological dysfunction has not been delineated. The present study has only succeeded in demonstrating that a relationship seems to exist. Identification of the relationship may indeed be complicated by the fact that diet-induced mood disturbances are unique only to a small segment of the population. Goldstein and Kaizer (1969) documented the highly idiosyncratic nature of a person's response to caffeine. It appears as though a similar phenomenon may exist for sucrose. Consequently, all individuals would not experience psychological distress as a function of diet. This means that some mechanism must be developed for identifying sensitive individuals. Currently, work is being conducted in an attempt to develop the BIMI as a selection instrument. If this proves fruitful, a mechanism will be available for the identification of sensitive individuals, and these individuals can be studied to assess dietary factors and the physiological mechanism resulting in the accompanying distress.

References


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