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MOOD AND BEHAVIOR (SMOKING AND SUGAR SNACKING) FOLLOWING MODERATE EXERCISE: A PARTIAL TEST OF SELF-REGULATION THEORY

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Summary—To study the effect of moderate exercise on self-rated mood and other behaviors, 5-min brisk walks were taken by smokers before a desired cigarette (Experiment 1; $N = 16$), or by frequent snackers before a sugar snack (Experiment 2; $N = 18$) on multiple occasions over 3-week periods. Self-ratings before and after exercise indicated that walks produced increased energy and reduced urge to smoke or snack. Also, the walks approximately doubled the time before smoking the next cigarette, or eating the next snack in free smoking and snacking conditions. This research provides some evidence for a self-regulation of mood model in which moderate exercise may sometimes be substituted for smoking or snacking on the basis of common mood effects.

In this theoretical analysis (Thayer, 1989), mood is assumed to be closely associated with central states of general bodily arousal with conscious components of energy (vs fatigue) and tension (vs calmness). This two-dimensional model of mood has gained increasing acceptance in recent psychological research, although the same two dimensions are sometimes given other descriptive labels (e.g. Positive and Negative Affect; Watson & Tellegen, 1985). Within the present theory, central mood states are seen as integrally related to other biopsychological variables including health, sleep and wakefulness, gross motor activity, ingestion of various nutritional substances, cognitive processes, and stress-related threat.

Relevant to the present research is an assumed elemental linkage between moderate exercise and mood (Thayer, 1989). Much of the empirical evidence for this comes from a number of studies by the senior author in which short brisk walks were found to have an immediate primary mood effect of increased energy, a secondary and somewhat weaker effect of reduced tension, and a tertiary effect involving subtle changes in states of optimism and the apparent seriousness of personal problems (Thayer, 1978, 1987a, b). These subtle transitory effects are especially apparent when the brisk walk occurs after a period of sedentary activity and at times when exhaustion is not present. The effects usually last only an hour or so after a 10-min walk.

The above walking research involved only moderate exercise with healthy and rested adults, and there is only limited research expanding these parameters. Most applicable to the present theoretical concept is the research by Steptoe and Cox (1988) which showed that the immediate effect of a session of low intensity exercise was enhanced vigor and exhilaration, a response consistent with increased subjective energy. Other research involving moderate exercise has generally shown this energy enhancement effect, and sometimes the tension reduction effect (Jin, 1989; McIntyre, Watson & Cunningham, 1990; Otto, 1990; Weinberg, Jackson & Kolodny, 1988; Williams, 1989). The immediate effect of strenuous exercise, on the other hand, has been energy reduction (Knapik, Staab, Bahrke, Reynolds, Vogel & O'Conner, 1991; Roth, 1989; Steptoe & Cox, 1988).* There are other relevent studies concerning moderate exercise and mood (e.g. Cramer, Nieman & Lee, 1991), but much of this involves long-term exercise programs and characteristic mood of participants.

*On the basis of anecdotal reports by regular exercisers, we believe that there is often energy enhancement from strenuous exercise an hour or so after the exercise occurs, even though fatigue may be the immediate effect. Some evidence for this delayed energy response may be found in an experiment by Flory and Holmes (1991) in which mood ratings of increased energy were obtained 55 min after vigorous aerobic exercise. However, this is not direct evidence since in that experiment *S*s were instructed to rate their mood for the previous 40 min.

The present research was part of a more general investigation of the ways that people self-regulate everyday mood states (Morris & Reilly, 1987; Thayer, 1989). We see the more or less continual process of mood-regulation as occurring consciously or nonconsciously, and involving a variety of substance uses or behaviors aimed at modulating dysphoric mood states or continuing positive moods (e.g. everything from caffeine, alcohol, nicotine or sugar, to TV watching). This is often a subtle process involving slight changes in preferences. Our research program includes the hypothesis that this self-modulation of mood particularly is influenced by feelings of energy and tension. Although mood-modulation may be associated with large numbers of behaviors and many underlying physiological mechanisms, we believe that to some extent these methods of modulation are interchangable so long as the satisfying mood occurs. One implication of this is that one substance or behavior may be substituted for another.

It is difficult to obtain definitive proof of the interchangeability of behaviors and substances, as well as proof of the process of mood regulation itself. However, there are many kinds of evidence suggesting that this substitution occurs with a variety of behaviors and substances (Morris & Reilly, 1987; Vuchinich & Tucker, 1988). To take one relevant example, smoking may be regarded as a form of mood-regulation, and smoking cessation often produces weight gain (Blitzer, Rimm & Giefer, 1977), probably because of increased caloric intake when cigarettes are not available (Wack & Rodin, 1982). Of course, this is a complex issue that is not fully understood, as one can see from the theory that the weight gain with smoking cessation may be due to changes in resting metabolic rate (Perkins, Epstein, Marks, Stiller & Jacob, 1989; Perkins, Epstein & Pastor, 1990).

The idea that food is a common mood regulator that may be used interchangeably with other substances is particularly consistent with a number of studies that have shown an increased attractiveness of sweet-tasting foods following smoking cessation (Grunberg, 1982, 1986; Grunberg, Bowen, Maycock & Nespor, 1985; Rodin, 1987). In a very general way, these changed preferences could be viewed as low awareness mood-regulation attempts; people deprived of one mood regulator (cigarettes) chose an alternative means of feeling better (tasty foods). For instance, in one recent study involving carefully monitored food ingestion during a well controlled smoking cessation program, quit dates were randomly assigned early and later in the program. Corresponding to each quit date there was a significant increase in calorie intake, and particularly increased ingestion of sucrose and fats (Hall, McGee, Tunstall, Duffy & Benowitz, 1989).

In the present research, the interchangeability hypothesis is based on the assumption that sugar snacking and smoking influence energy and tension states, and there is evidence that this is the case. For example, in one experiment the popularly assumed "sugar high" was observed following ingestion of a sugar snack. This involved a reliable pattern of postingestion increases in energy feelings followed by reduced energy and increased tiredness 1 to 2 hr after ingestion (Thayer, 1987a). Also, a number of studies suggest that some people reduce anxeity by eating (Ruderman, 1986). This is particularly true of restrained eaters (dieters).

Although the motivation for smoking is often thought to be understood with the concept that nicotine is an addictive substance (Warburton, 1989), a more balanced analysis focuses upon the various mood-related benefits that people derive from the behavior (Eysenck, 1991). In particular, the energy enhancing and tension reducing effects of smoking are suggested by survey data (Ikard, Green & Horn, 1969; Frith, 1971; Russell, Peto & Patel, 1974). Of course, it has been known for some time that nicotine has a biphasic effect on psychological manifestations of arousal, including increased alertness and decreased anxiety (Eysenck, 1980). The physiological substrates of energy increases may be guessed from recent observations that smoking produces basic metabolic increases (Perkins *et al.*, 1989, 1990). The biphasic psychological and physiological effects of nicotine may occur because the substance appears to produce central nervous system (CNS) arousal and skeletal–muscular deactivation (Gilbert, 1979).* Such a pattern is likely to be associated with energy enhancement and tension reduction (Thayer, 1989).

Since the present research in part is aimed at studying the interchangeability of mood effects obtained from moderate exercise, other evidence which indicates that exercise can suppress both snacking and smoking is relevant. Temporary appetite suppression from exercise is suggested from

*Alternatively, Eysenck (1980) has hypothesized that the biphasic response may be due to the amount of nicotine in the blood stream with smaller amounts increasing arousal and larger amounts decreasing arousal.

different lines of research. For example, classic studies with rats led Mayer and his associates to conclude that food intake first decreases with moderate exercise, and then increases with more intense exercise (Mayer, Marshall, Vitale, Christensen, Mashayekhi & Stare, 1954). A number of animal studies, but not all, have supported this model (Titchenal, 1988).

Human studies of appetite suppression are more difficult to control, but some support has also been provided from these. For example, in one experiment, appetite ratings were suppressed immediately following 30 min of treadmill exercise at 50% VO_2 max (Reger, Allison & Kurucz, 1984), but the suppression effect was absent after 1 hr. In another study, appetite was suppressed for 120 min following 60 min of walk/jogging exercise at 50% VO_2 max, and also following 30 min of exercise that alternated between 40 and 100% VO_2 max (Reger & Allison, 1987). In a third experiment (Thompson, Wolfe & Eikelboom, 1988), exercise involving rapid energy expenditure (4.1 kcal/kg body weight achieved through 68% VO_2 max) produced appetite suppression, but less rapid expenditure of equivalent energy did not.

Studies of the relationship between smoking and exercise have also provided some support for a suppression effect. In one experiment comparing 30 min of sustained high exercise with a control exercise condition designed to simulate normal daytime activity, the high exercise condition resulted in self-ratings of decreased desire for cigarettes that approached statistical significance (Pomerleau, Scherzer, Grunberg, Pomerleau, Judge, Fertig & Burleson, 1987). The suppression effect was sufficiently notable for the authors to indicate that 3 of the 10 *S*s asked if they were required to smoke following the high exercise condition.

Other studies provide somewhat less direct evidence of the suppression effect. For example, following acute myocardial infarction, exercise training resulted in reliable reductions in self-reported cigarette consumption at 28 weeks compared to nontrained controls (Taylor, Houston-Miller, Haskell & Dubusk, 1988). In another study involving a 5-year follow-up of a fitness program, 70% of those remaining active had given up smoking while only 10% of inactives stopped smoking (Sedgwick, Taplin, Davidson & Thomas, 1988). And in a large-scale study involving measured physical fitness, there was a significant association between lower smoking rates and increasing levels of physical activity for all but older females. Considering the sample as a whole, those who quit smoking were more likely to be physically active (Faulkner, Baily & Mirwald, 1987). Finally, in a recent experiment, 7-day smoking abstinence rates were significantly greater among exercisers than among nonexercisers (Marcus, Albrecht, Niaura, Abrams & Thompson, 1991). This type of evidence is not unequivocal, however, because other research has shown no reliable effect on smoking rates from programmed physical conditioning (Blair, Goodyear, Wynne & Saunders, 1984; Russell, Epstein, Johnson, Block & Blair, 1988; Hill, 1985).

The present research was designed to produce additional evidence about the relationship between exercise and mood, and further to study wider behavioral effects of exercise that may be mood-related. In particular, on the basis of previous research we hypothesized that short brisk walks would primarily increase energy, and secondarily reduce tension.

Additionally, we sought to partially test the general hypothesis outlined above that different means of modulating mood are interchangeable, and that one means of enhancing mood can be substituted for another. For this test, we reasoned that if smoking and sugar-snacking are commonly used as mood regulators, and particularly for energy enhancement and tension reduction, then brisk walks which produce the same mood effects should temporarily reduce both the urge to smoke and to snack. Accordingly, two experiments were designed in which we hypothesized that moderate exercise would simultaneously increase energy and reduce urge and use of cigarettes (Experiment 1) and sugar snacks (Experiment 2).

EXPERIMENT 1

Method

Five male and 11 female smokers (1–2 packs/day), between 18 and 44 years, volunteered to conduct self-observations on 12 separate occasions in whatever natural setting they happened to be. Some were paid a $15.00 token fee, but most participated because of a promise of complete postexperiment feedback that would provide useful personal information. The *S*s were unfamiliar

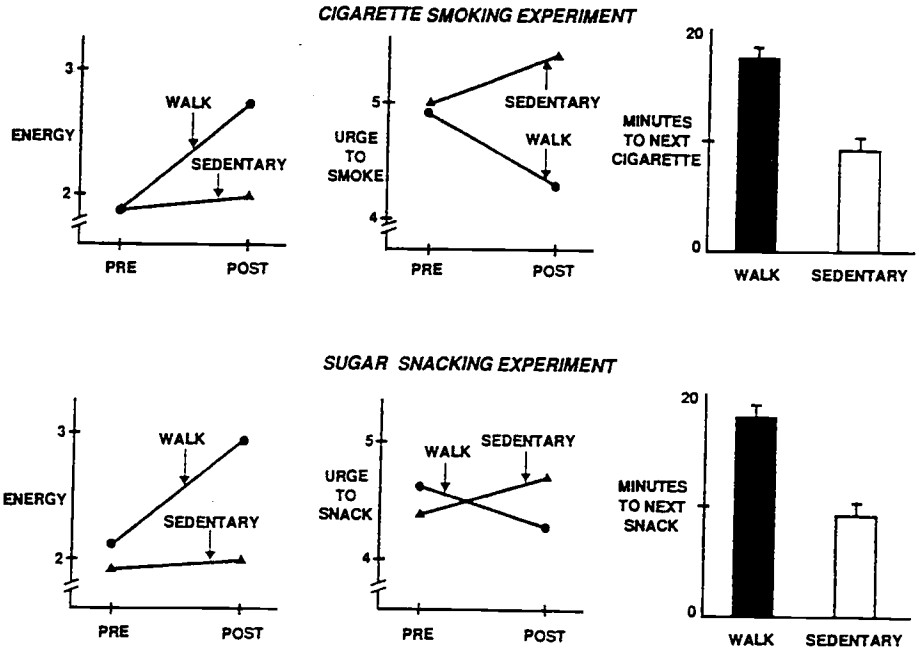

Fig. 1. Effects of moderate exercise on mood and behavior (smoking and snacking).

with the research program or the experimental hypotheses. Since there were multiple ratings required, *S*s were also cautioned to consider their feelings only at the moment of making each rating, and not to think about any other rating that was made. Each experimental occasion was initiated by a period of sedentary activity of at least 45 min during which no smoking, eating or drinking occurred.

Premanipulation levels of energy, tension and smoking urge, were assessed by a Short Form AD ACL (Thayer, 1986) and a 7-point Likert-type rating of present urge to smoke, respectively. The AD ACL is a commonly-used measure of momentary mood states that has been validated in a variety of psychophysiological and biopsychological studies (Thayer, 1989). It involves 20 self-descriptive adjectives with which the individual rates current feelings. In this study the 2 relevent subscales were Energy (energetic, lively, active, vigorous, full-of-pep), and Tension (tense, clutched-up, fearful, jittery, intense). The present urge-to-smoke rating ranged from "extreme" urge to "none at all".

Thus, each of the 12 experimental occasions that were required of all participants was initiated only after a period of at least 45 min of sedentary activity. Following this sedentary precondition, *S*s completed self-ratings and then uncovered a message that instructed either a 5-min brisk walk in the immediate vicinity or 5 min of sedentary activity as previously engaged (block randomly distributed across the 12 occasions). Immediately after the designated condition, the individual completed mood and urge self-ratings a second time, and then was free to smoke whenever he or she chose. Participants were instructed to carefully note time of smoking the next cigarette.

In the walk condition, participants were instructed to walk rapidly, as they might if they were late for an appointment, but not so rapidly that exhaustion occurred. No requirement was imposed on the control condition except that it be sedentary and that it continue the previous activity of the participant. Analyses of protocols indicated that in the no-exercise control condition, 47% of occasions involved reading, studying or paperwork; 19%, TV watching; 14%, talking or listening to the radio, music or college lectures; and 20%, other sedentary activities.

Results

Statistical analysis involved $2 \times 2 \times 6$ repeated-measures ANOVAs. A test of the interaction effect for walk–no-walk vs pre–post, indicated that walking significantly decreased rated urge to smoke compared to not walking, $F(1, 15) = 7.82$, $P < 0.01$. Perhaps more importantly, the time

until smoking the next cigarette was extended in the walk condition by over 50%, (mean walk = 16.9 min; mean no-walk = 9.1 min), $F(1, 15) = 10.87$, $P < 0.01$. As expected, walking significantly raised subjective energy, $F(1, 15) = 20.75$, $P < 0.01$. Figure 1 summarizes these results. However, the walk did not produce the expected decline in subjective tension. The ANOVA occasions effects (1st to 6th testing day in each condition), which indicate whether the results changed during the 3 weeks of the study, were nonsignificant for all measures.

EXPERIMENT 2

Method

The voluntary participants in this experiment included 7 male and 11 female frequent sugar snackers (18–52 years). The same design and procedure was employed as in Experiment 1 (including walk–no-walk, pre–post, 6 occasions per condition). Instructions to *S*s were also the same, except that in this case, participants viewed and thought about the snack immediately before the pretest as a means of activating the snack urge. The candy was then put out of sight until *S*s chose to eat it. The sugar snack was any one of several standard-sized candy bars of choice. Protocols of the no-exercise control condition indicated that 27% of occasions involved reading, studying or paperwork; 29%, TV watching; 24%, talking or listening to the radio, music or college lectures; and 21%, other sedentary activities.

Results

Consistent with the previous results, the interaction effect indicated that walking significantly decreased rated urge to snack compared to not walking, $F(1, 17) = 12.32$, $P < 0.01$. The time until eating the next snack was extended by walking almost 50%, (mean walk = 17.2 min; mean no-walk = 12.2 min), $F(1, 17) = 8.50$, $P < 0.01$. The walk also significantly raised subjective energy, $F(1, 17) = 19.91$, $P < 0.01$. Figure 1 summarizes these results. In this experiment, the walk produced an expected decline in subjective tension, $F(1, 17) = 3.08$, $P < 0.05$ (one-tailed test). The occasions effects were nonsignificant for all measures.

GENERAL DISCUSSION

As hypothesized, in both experiments short brisk walks produced reliable increases in energy feelings. These findings are consistent with previous research showing this subjective state to be the primary mood effect of moderate exercise (Thayer, 1978, 1987a, b). Also, the fact that a tension reduction effect was found in Experiment 2, but not found in Experiment 1, is consistent with previous research showing tension reduction to be only a secondary effect of moderate exercise. One reason why tension reduction did not occur in the first experiment may have been a naturally occurring and increasing tension experienced by addicted smokers who have waited at least 50 min between cigarettes. Thus, the 5-min walks apparently were sufficient to produce the primary energy effect, but may have been of insufficient intensity to overcome the rising tension of smokers in need of a cigarette.

In addition to the mood effects, these results indicate a wider behavioral effect from moderate exercise. The brisk walks taken prior to smoking a cigarette or before eating a sugar snack reduced the urge to smoke or to snack. Moreover, the walks considerably lengthened the time until the next cigarette was smoked or the next snack was eaten. The similarity of the suppression of two seemingly different behaviors is notable in relation to the theory that partly underlies this research.

Physiological mechanisms specific to smoking and exercise, and to snacking and exercise, may have largely determined the reductions, but we believe that the common mood effects, and particularly energy increases, also influenced these reductions. Thus, these results in part may be interpreted with self-regulation theory, and particularly the idea that different means of modulating mood are interchangeable so long as the desired mood effect occurs. Of course, from these data we cannot be sure that the enhanced energy, which is derived from exercise, influenced the reduction in smoking and snacking. The 3 variables are merely correlated in a way consistent with the theory. Such a firm causal conclusion must await further evidence. Nonetheless, the theoretical construct is strengthened by the results.

In both experiments, subjective energy covaried with urge and behavior (smoking and eating time), but tension did not show this covariation in Experiment 1. Therefore, if one assumes the theoretical construct of interchangeability based on a common mood effect, these results suggest that energy rather than tension is the more important intervening mood variable. Subjective energy has been observed to covary with a variety of other biological conditions, and this suggests that energetic arousal has an important central function. For example, evidence indicates that subjective energy is related to general health, sleep, time-of-day, stress and depression, as well as exercise and nutrition (Thayer, 1989). Subjective energy also appears to covary with a variety of cognitive effects, including perception of personal problems, optimism, and self-esteem. Therefore, the temporary energy enhancing effects of short brisk walks suggest that this activity may have wider psychological and medical benefits.

Information derived from those results may have practical value for smoking and snacking reduction programs in which a natural means to temporarily overcome strong urges would have immediate use. A good deal of current evidence now indicates that exercise is beneficial for general health (e.g. Blair, Kohl, Paffenbarger, Clark, Cooper & Gibbons, 1989; Paffenbarger, Hyde, Wing & Hsieh, 1986), but based on the present research it is likely that even a small amount of moderate exercise could have direct health benefits through at least some reduction of smoking and sugar snacking. It is relevant to note, however, that in our experiments, no attempt was made to produce overall smoking or snacking cessation, only temporary delay. Indeed, the mere knowledge and practice of this form of exercise among smokers and among dieters could have only limited value for smoking and snacking cessation. The more likely value of this knowledge is that it would be used as part of a more general smoking or snacking cessation program, being applied mainly on those occasions when the urge to abandon a smoking or snacking cessation program must be temporarily overcome (cf. O'Connor & Stravynski, 1982).

The results of this research appear to be fairly straightforward. When *S*s exercised before smoking or snacking, the urge and the actual behavior were reduced compared to times when *S*s engaged in a sedentary activity. These results are consistent with a number of studies reviewed above that employed different methodologies, and in which there were indications that exercise acted at least as a temporary suppressor to both smoking and snacking. However, experiments such as the present one are inevitably complex, and alternative explanations for the findings are possible. In the remainder of this paper, let us deal with some of these alternatives.

One competing explanation for the results is that the observed smoking and snacking reduction resulted not from the mood effects of exercise but rather from some other unintended effect of the experimental manipulation, for example, simple distraction from smoking or snacking urges. Although the present design does not preclude this explanation, we think it is unlikely for several reasons. First, we must indicate that this distraction explanation depends on the interpretation that the smoking and snacking reduction were due to some sort of cognitive effect (cf. McCaul & Malott, 1984) rather than to mood change brought about by the exercise. If distraction were assumed to be the basis of this effect, however, it would appear that the sedentary condition with its much greater cognitive involvement would produce the greatest distraction. This is because in the sedentary condition, after the pretest, *S*s engaged in such activities as reading, studying, or TV watching.

In the walk condition, however, there was no particular cognitive involvement; walking was the main activity. Furthermore, a number of studies (Thayer, 1978, 1987a, b) as well as the present one have demonstrated that a primary mood effect of short brisk walks is energetic arousal. Also, interpreting these results within the context of a self-regulation concept adds to a construct validation of our theoretical analysis. Thus, the mood effect seems to be a better explanation for the urge reduction than distraction. But whether the mood effects explain the urge reduction or not, exercise-produced change rather than mental distraction is suggested as an underlying basis of the observed suppression, first by a variety of kinds of previous research showing that exercise reduces urge to smoke and to snack, and second by our cognitively-oriented control condition.

Another alternative explanation for the present results involves subject expectation effects. With this kind of intraindividual design involving self-ratings, the possibility always exists that *S*s somehow might have guessed the purpose of the research and cooperated by giving expected results. However, this alternative explanation is unlikely for several reasons. First of all, the participants

were unaware of the experimental hypotheses. A second point is that they were expressly warned to be scrupulously honest lest the experiment be invalidated. Since their motives for experimental participation were in large part greater self-knowledge, there would be no reason for them not to carefully follow directions.

The third, and perhaps most important reason to doubt expectation effects is that the ANOVA occasions effects were nonsignificant in both experiments. If expectations were responsible for the results, one would assume that the experimental effects would grow stronger over the 3 weeks of the study as participants were more likely to guess the reasons for the experiment. However, the nonsignificant ANOVA occasions effects indicate no consistent change in the results over time.

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