

The Effects of Contingent-Monetary Reinforcement and Music on Exercise in College Students

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The effects of response-contingent monetary reinforcement and continuous background music on cycling were examined. Twenty-five college students rode a stationary exercise cycle to exhaustion or 45 min. Each participant cycled under each of 4 conditions. In the music condition the participant's favorite music was played. In the money condition, the participant earned \$0.15 every 40 pedal rotations. Under the music plus money condition, participants earned money in the presence of background music. In the control condition neither music nor money were presented. The order of conditions was completely counter-balanced. The number of minutes riding the cycle and the rate of riding were significantly higher under the money and the money plus music conditions compared to the control and the music conditions. Music significantly increased the rate of cycling but did not affect cycling time. Music did not enhance the effects of money on cycling. Response-contingent money and playing background music can significantly increase a participant's workout effort, but the effect of contingent money is much more powerful than music.

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Despite the positive relation between exercise and health, most people do not maintain an exercise program for an extended period of time (e.g., Dishman, 1984). Considerable research has focused on discovering variables that can increase the likelihood and intensity of exercising. Watching videos (e.g., Cohen, Chelland, Ball, & LeMura, 2002; Robergs, Bereket, & Knight, 1998) and listening to music (e.g., Karageorghis & Terry, 1997) can increase the intensity of exercise, as well as ratings of perceived exertion. Contracts between participants and experimenters can increase the attendance at exercise sessions (e.g., Epstein, Wing, Thompson, & Griffin, 1980; Wysocki, Hall, Iwata, & Riordan, 1979).

A very promising method for enhancing the intensity of exercise, that has received relatively little attention, is the presentation of response-contingent reinforcement. With response-contingent reinforcement, reinforcers are presented throughout the exercise session, and the rate of reinforcement may depend upon the participant's performance. For example, money may be presented to a person riding a stationary cycle after every 20 rotations of the pedals (Cohen et al., 2002). In this case, longer and faster cycling result in higher frequencies of reinforcement. This approach contrasts with behavioral contracts in which reinforcers are presented after 1 week or even after 6 months of exercising, and reinforcement depends on exercise participation and not on the intensity of exercising (e.g., Epstein et al., 1980; Wysocki et al., 1979).

De Luca and Holborn (1985, 1990, 1992) examined the effects of contingent reinforcement on exercise in children. In one experiment two obese and two nonobese 11-year old boys rode a stationary cycle (De Luca & Holborn, 1985). Baseline cycling time and rate of pedaling were initially established. In the second condition, the boys were told that they could earn points for riding the cycle, and that they could later exchange the points for arts, crafts, and games. The points were delivered according to a fixed interval 1-min schedule of reinforcement. Under this schedule, the first rotation of the pedals after 1 min turned on a light and a bell, and the boys earned one point. In the last condition of the experiment the baseline (no points) was redetermined. Response-contingent reinforcement substantially increased cycling time. In two similar studies, De Luca and Holborn (1990, 1992) showed that response-contingent reinforcement increased the rate and the duration of cycling when points were delivered according to fixed-ratio (FR) and variable-ratio schedules of reinforcement.

Three studies examined the effects of contingent reinforcement on exercise in adults. Libb and Clements (1969) increased cycling of four geriatric patients with contingent reinforcement. Geiger, Todd, Clark, Miller, and Kori (1992) increased walking speed in chronic pain patients with contingent verbal reinforcement and tokens. Cohen et al. (2002) examined the effects of contingent money on cycling in two female college students. Participants were told that they earned \$0.05 every time they turned on a light and a tone while riding a stationary

cycle. The light and tone were turned on after every 20 (FR 20 schedule) or every 40 (FR 40 schedule) rotations of the pedals. Each participant was given a tally of the amount of money she earned after each session, but the money was not delivered until the experiment was over. The money increased cycling time in one participant, but did not affect the second participant.

In light of the relative scarcity of research on the effects of contingent reinforcement on exercise, the present experiment further explored this variable. In some ways, this experiment resembled the Cohen et al. (2002) study. However, several changes were made to increase the likelihood of discovering a functional relation between reinforcement and exercise. Cohen et al. (2002) studied two participants with a single-subject experimental design. The present study increased the sample size and used a separate-groups experimental design. In the present experiment, 25 participants were tested in four separate exercise sessions. Cohen et al. (2002) used only \$0.05 as a reinforcer, and the present study increased the amount to \$0.15. Cohen et al. (2002) turned on a light and a tone for 1 s following the completion of each FR schedule. Reinforcement was made more salient in the present study by positioning a row of nine lights in front of the participant with an electro-mechanical digital counter to the right of the lights. The lights turned on incrementally as the participant pedaled the cycle and the counter audibly incremented 15 times when all of the lights were on. Finally, Cohen et al. (2002) gave money to each participant at the end of the experiment, whereas we presented money at the end of the session.

In addition to examining the effects of contingent reinforcement, the present study examined the effects of music on cycling. Research has shown that music can increase exercise duration and heart rate and lower ratings of perceived exertion (e.g., Anshel, & Marisi, 1978; Copeland & Franks, 1991; De Bourdeaudhuij et al., 2002; Szmedra & Bacharach, 1998; Thornby, Haas, & Axen, 1995), although the effects of music on exercise are not always consistent (e.g., Boutcher & Trenske, 1990; Brownley, McMurray, & Hackney, 1995; see Karageorghis & Terry, 1997 for review). The present study attempted to ascertain if music could enhance the effects of response-contingent reinforcement: Perhaps playing background music in combination with monetary reinforcement can enhance exercise performance. Participants rode a stationary exercise cycle on four separate sessions and received money, music, money plus music, and no music or money. It was hypothesized that background music and contingent money would each increase the rate and duration of cycling, and that background music would enhance the effects of contingent money.

Method

Participants

Twenty-five students (5 males and 20 females) between 18 and 29 years of age were recruited from physical education and psychology classes. Participants received class credit for their participation. The Bloomsburg University Institutional Review Board approved the experimental protocol, and informed consent was obtained from each participant.

Apparatus

Participants exercised on a SensorMedics 800 electronically braked cycle ergometer (SensorMedics, Yorba Linda, CA). The electronic controls of the cycle were turned away from the participants' view. A 16 cm tongue depressor was taped to the right pedal of the cycle. With each full rotation of the pedal, the tongue depressor passed through a photoelectric beam (Coulbourn Instruments, Allentown, PA) and recorded a response. A Polar Heart Rate (HR) Monitor (Port Washington, NY) measured heart rate. Directly in front of the participant (244 cm) at eye level was a row of nine 28 V colored (blue, orange, red) circular jeweled lights. Each light was 12 mm in diameter and spaced 8 mm apart, edge-to-edge, and part of a triple-cue lamp module from Coulbourn Instruments (Allentown, PA). An electromechanical counter was positioned 10 cm to the right of the lights. A compact disc player was used to play the participants' favorite music that he/she brought each session. A small fan was turned on during each session. The arrangements of experimental contingencies, presentation of stimuli, and data recording were accomplished with solid-state programming modules located behind the participant (Coulbourn Instruments, Allentown, PA). The experiment was conducted in a 3.80 m x 3.5 m x 2.75 m room with no windows.

Procedure

A 2 x 2 within-factor design was used. The factors were monetary incentive (no money, money) and the presentation of an auditory stimulus (no music, music). Each participant was tested under four conditions: control (no music, no money), the presentation of music during the entire session, the presentation of money contingent upon a fixed number of pedal rotations, and the combination of money and music. Since all participants were tested four times, the order of conditions was completely counterbalanced. With four treatments, there were 24 different sequences, and one participant was randomly assigned to each of the 24 sequences. Due to an oversight, two participants were tested under the same order, thus accounting for 25, not 24, participants. Each experimental session was separated by 1 to 3 days.

Initial session. During the first session, each participant's age-predicted maximum HR (APMHR) was calculated using the formula: $APMHR = 220 - \text{age}$ (Wilmore & Costill, 1994, p. 177). The experimenter instructed the participant to remove his/her watch during the session. The HR monitor was adjusted to fit the subject snugly, and the monitor was placed under the pectoralis muscle. The experimenter held the HR monitor watch in order to record HR. The seat height was adjusted for each participant, and the participant was instructed to begin pedaling at a constant rate of 50 revolutions per min, with feedback provided to pedal faster or slower. The initial pedal resistance was 20 W, and the resistance was increased 10 W every 60 s until the participant reached 60% of their APMHR. The cycle's resistance was recorded at this time and served as the exercise resistance for the experimental sessions.

Warm-up. Each session began with a 2-min warm-up, during which the cycle's resistance was 50% of the participant's final resistance setting. During the warm-up, the experimenter read the instructions. Each participant was told to push himself or herself to get a good workout, and that the session terminated when the participant stopped pedaling or 45 min elapsed, whichever came first. Instructions emphasized that pedaling should not stop unless the participant was too tired to continue, and that resting or taking breaks was not permitted. Participants were instructed to ride at their own speed, and on only one occasion was a participant told to speed up when their pedaling rate fell below 50 revolutions per min. Talking was not permitted during the sessions.

Experimental sessions. During the control session, the participant rode the cycle without background music or money. During the music session, the participant's favorite music was played during the entire session, not including warm-up. The volume was adjusted to fit the participant's preference. During the money condition, the experimenter informed the participants that they could earn money as they rode the cycle. The participant was told that the nine colored lights situated in front of the cycle would turn on as they pedaled. After all of the lights were turned on, further pedaling would operate a counter positioned to the right of the lights, indicating that they earned 15 cents. Participants were told that they could earn as much money as they wanted during the session, they would be paid immediately after the session, and that the faster they pedaled the more money they could earn. After the completion of every 40 pedal rotations (i.e., a FR 40 schedule of reinforcement) \$0.15 accumulated on the counter. Four revolutions of the pedals illuminated one light at a time, left to right. After 36 pedal rotations all of the lights were on, and four more pedal rotations turned off the lights and incremented the counter 15 times, at a rate of one increment every 0.3 s. Each counter operation was accompanied by an audible click. The participant was given the money immediately after the session and was told not to talk to other participants about the money condition. During the music and money condition, the FR 40 schedule was in effect, and music was played during the entire session.

Results

The number of minutes each participant rode the cycle and the number of revolutions of the pedals were recorded. Riding rate (revolutions per minute) was calculated by dividing the number of pedal revolutions by session time. The time and rate data were analyzed separately by a 2 x 2 within-factor analysis of variance. The factors were monetary incentive (no money, money) and the presentation of an auditory stimulus (no music, music). *A priori* dependent *t* tests were conducted to compare performance under the control condition with the music condition, and performance under the money condition with the money plus music condition. The percentage of change in cycling time and cycling rate under the music, money, and money plus music conditions from the control condition was calculated for each participant. The percentage of change from control data were analyzed by one-sample *t* tests to determine if the change in performance was significantly different from 0% (i.e., no change from control).

Figure 1 (upper panel) shows the number of minutes participants rode the cycle under control (no music and no money), music, money, and money plus music conditions. Data are means of each group and standard errors of the mean. Monetary incentive significantly increased cycling time, $F(1, 24) = 13.60, p = .0012$. The effect size (partial Eta squared) for monetary incentive was 0.36, and power was .96. The overall mean cycling time under the two no-money conditions was 34.0 min compared to 40.0 min under the two money conditions. There was no significant effect of auditory stimulus, $F(1, 24) = 0.16$, and no monetary incentive x auditory stimulus interaction, $F(1, 24) = 0.34$, on cycling time. *A priori* comparison dependent *t* tests showed no significant difference in cycling time between control and music conditions or between money and money plus music conditions. The mean increase in cycling time from the control condition was 9.3%, 33.4%, and 35.8% for the music, money, and money plus music conditions, respectively. One-sample *t* tests showed that a change of 9.3% in the music condition from the control condition was not a significant increase from 0%, $t(24) = 1.31$. The percentage increases under the money and money plus music conditions were significantly greater than 0%, $t(24) = 3.07, p = .0053$ and $t(24) = 3.01, p = .0061$, respectively.

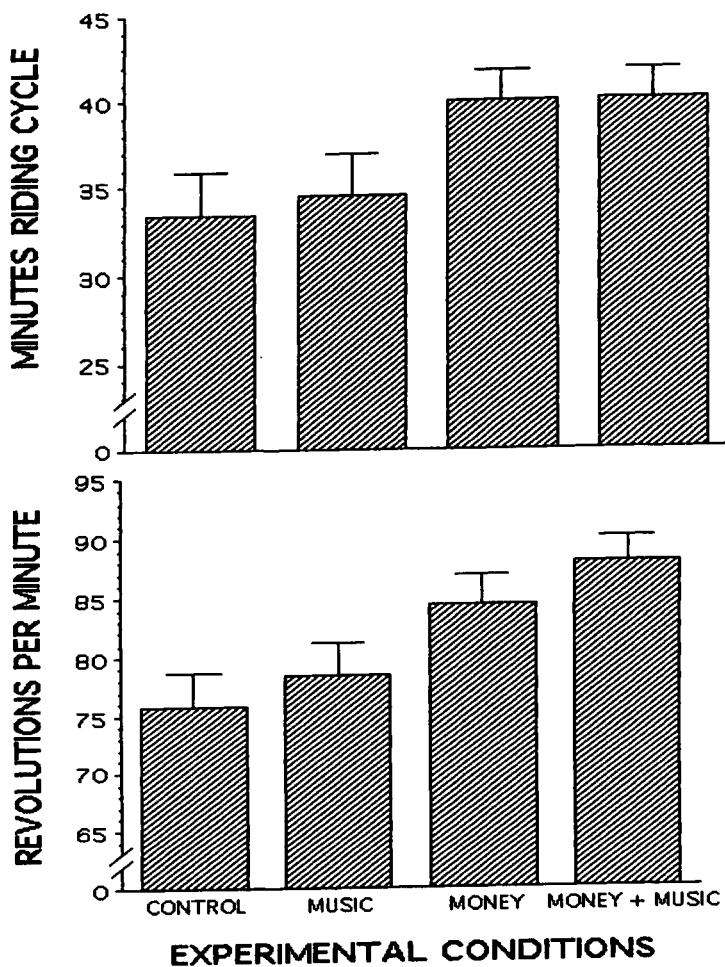


Figure 1. Top Panel. The number of minutes spent riding the cycle until participants stopped riding or 45 min elapsed. Data are means and standard errors of the mean for the four conditions of the experiment. *Bottom Panel.* The revolutions per minute under the four conditions of the experiment. Data are means and standard errors of the mean.

Figure 1 (bottom panel) shows the revolutions per minute under control, music, money, and money plus music conditions. Data are means of each group and standard errors of the mean. Monetary incentive significantly increased the rate of cycling, $F(1, 24) = 46.41, p < .0001$. The effect size for monetary incentive was 0.66, and power was .99. The overall mean cycling rate under the two no-money conditions was 77.1 revolutions per min compared to 86.0 revolutions per min under the two money conditions. Playing music significantly increased the rate of cycling, $F(1, 24) = 5.64, p = .0259$. The effect size for auditory stimulation was 0.19, and power was .62. The overall mean cycling rate under the two no-music conditions was 80.0 revolutions per min compared to 83.1 revolutions per min under the two music conditions. The monetary incentive $\times$ auditory stimulus interaction, $F(1, 24) = 0.123$, was not significant. A priori comparison dependent t tests showed no significant differences in cycling rate between control and music conditions or between money and money plus music conditions. The mean increase in the rate of cycling from the control condition was 4.5%, 12.8%, and 18.1% for the music, money, and money plus music conditions, respectively. A 4.5% change under the music condition from the control condition was significantly higher than 0%, $t(24) = 2.07, p = .0493$. The percentage increases under the money and money plus music conditions were also significantly greater than 0%, $t(24) = 4.139, p = .0004$ and $t(24) = 6.131, p < .0001$, respectively.

Table 1 presents summary statistics (mean, standard deviation, and range) under each of the four experimental conditions for session time, cycling rate, number of FR 40 schedules completed, and amount of money earned per session. Also presented is the number of participants (out of 25) who rode the cycle for 45 min before the session was terminated by the experimenter. The data in Table 1 support the data presented in Figure 1. For example, an examination of the ranges shows that the lowest cycling rate was 50.5 revolutions per min under the control condition and 71.2 revolutions per min under the money + music condition. Table 1 also shows that the music and the money increased the number of FR schedules completed and the amount of money participants earned. The number of participants who rode the cycle the entire 45 min session increased under the money and music conditions compared to the control and music conditions, although the difference across conditions was not significant (Goodness of Fit Chi Square).

Table 1. Mean, Standard Deviation, and Range of Session Length, Cycling Rate, Completed FR 40 Schedules, Money Earned, and Number of Participants Who Terminated the Session at the 45 Min Maximum

	<u>CONTROL</u>	<u>MUSIC</u>	<u>MONEY</u>	<u>MONEY+MUSIC</u>
<u>MINUTES RIDING CYCLE</u>				
M	33.4	34.5	39.9	40.0
SD	12.3	11.9	8.5	8.8
Range	10.4-45	11.8-45	12.7-45	15.1-45
<u>REVOLUTIONS PER MINUTE</u>				
M	75.7	78.4	84.2	87.8
SD	14.7	13.5	13.2	10.5
Range	50.5-107.8	53.5-111.1	51.2-112.4	71.2-110.9
<u>NUMBER OF FR 40 SCHEDULES COMPLETED</u>				
M	63.8	68.2	72.9	74.8
SD	29.6	27.9	19.8	19.3
Range	14-121	5-125	16-103	28-102
<u>DOLLARS EARNED PER SESSION</u>				
M	9.57	10.23	10.93	11.23
SD	4.44	4.18	2.97	2.89
Range	2.10-18.15	2.25-18.75	2.40-15.45	4.20-15.30
<u>NUMBER OF PARTICIPANTS WHO RODE CYCLE 45 MINUTES</u>				
	11	12	16	17

Each participant experienced each of the four conditions in a different order. To see if the order of conditions affected the data, separate 4×4 , two between-factor analysis of variances were performed on cycling time and cycling rate. The two factors were experimental condition (control, music, money, money plus music) and the order that the condition was conducted (first, second, third, forth). Although each participant underwent every treatment condition, experimental condition was treated as a between factor because it was impossible to pair the same person across order and condition. There was a significant difference in cycling time and cycling rate among the four conditions, $F(3, 84) = 2.723, p = .0490$ and $F(3, 84) = 4.54, p = .0053$, respectively. Most importantly, there were no significant order effects or order $\times$ condition interactions for cycling time [$F(3, 84) = 0.95$ and $F(9, 84) = 1.28$, respectively] or cycling rate [$F(3, 84) = 0.26$ and $F(9, 84) = 1.25$, respectively], indicating that the order of conditions did not play a significant role in this experiment.

The data presented above show that money significantly increased the average amount of time on the cycle and the average rate of cycling, and that music significantly increased cycling rate. We also wanted to see the extent to which individual performances conformed to the average performance. Cohen et al. (2002) reported that only one of two participants showed a functional relation between cycling performance and response-contingent money. The cycling rate for every participant was ordered from the lowest to the highest across the four conditions (individual data available upon request). Money, either alone or in combination with music, produced the highest cycling rate out of the four testing sessions in 23 of 25 participants. The money plus music condition produced higher cycling rates than the control condition in 23 of 25 participants. The money-alone condition produced higher cycling rates than the control condition in 21 of 25 participants and produced higher cycling rates than the music-alone condition in 19 of 25 participants. The music-alone condition produced higher cycling rates than the control condition in 15 of 25 participants. A similar analysis of the cycling time data is not presented because a large number of participants rode the cycle for 45 min (i.e., maximum session length) under several experimental sessions (see Table 1).

Discussion

Response-contingent monetary reinforcement and music significantly increased performance on a stationary cycle. Money affected exercise more than music did. Money significantly increased the rate of cycling and the time riding the cycle, whereas music only increased cycling rate. The effect size of monetary incentive on cycling rate was 0.66 compared to 0.19 for auditory stimulus. The percent increases in cycling rate under the money and money plus music conditions compared to the control condition was 12.8% and 18.1%, respectively, but

only 4.5% under the music condition. The percent increases in cycling time under the money and money plus music conditions were also relatively large at 33.4% and 35.8%, respectively, compared to a nonsignificant increase of 9.3% under the music condition. Analysis of the individual data supports this conclusion: The money-alone condition produced higher cycling rates than the control condition in 21 of 25 participants, whereas the music-alone condition produced higher cycling rates than the control condition in 15 of 25 participants. Music did not enhance the effect of money: There were no significant differences in cycling time and cycling rate between the money alone and the money plus music conditions. More participants cycled for the entire 45-min session under the money and money + music conditions compared to the control and music conditions (see Table 1), although the differences were not significant. These data suggest that if the session length were extended or if the participants determined the maximum session length, greater differences in cycling time among conditions might have been observed. In this regard, cycling rate appeared to be a more sensitive dependent variable than cycling time: Both independent variables (incentive and auditory stimulus) significantly affected cycling rate but only incentive significantly affected cycling time. The lack of sensitivity of cycling time to auditory stimulus most likely stemmed from terminating the session at 45 min. Table 1 shows that many participants in all four groups rode the cycle for the entire session length, thus masking possible differences among groups. Since incentive had a stronger treatment effect than auditory stimulus, a significant effect of incentive on cycling time was revealed despite the procedural limitation.

These data are consistent with the data reported by Cohen et al. (2002) who showed that presenting \$0.05 under FR 20 and FR 40 schedules of reinforcement increased the time on the cycle for one out of two participants. In the present study, money increased both the cycling rate and the time on the cycle in the large majority of participants. Several changes in the present study were made from Cohen et al. (2002), and it is impossible to isolate one variable that could account for the more consistent results that we observed. The most likely variable was the increase in the amount of reinforcement from \$0.05 to \$0.15. Other changes included making reinforcement delivery more salient by turning on a series of lights as the FR 40 neared completion, incrementing an audible electromechanical counter at the completion of each FR, delivering money more immediately at the end of the session rather than at the end of the experiment, and using fewer exercise sessions in the context of a separate-group experimental design rather than many sessions in a single-subject experimental design. Future research may isolate the effects of these variables. For example, not only did the money and money + music conditions present response-contingent money, they also presented response-contingent visual and auditory stimuli: Every fourth pedal rotation turned on a cue light and after all of the cue lights were on, auditory stimuli from the electromechanical counter were presented.

These visual and auditory stimuli might be considered conditioned reinforcers because of their temporal association with monetary reinforcement. However, it is possible that the visual and auditory feedback reinforced cycling in the absence of the money.

This study is one of only three experimental studies that have examined the effects of response-contingent reinforcement on exercise in adults. In addition to Cohen et al. (2002), Geiger et al. (1992) used contingent reinforcement to increase walking speed in chronic pain patients. Three experiments by De Luca and Holborn (1985, 1990, 1992) showed that response-contingent reinforcement increases cycling performance in children. Those studies resembled the present study in many ways. In the De Luca and Holborn studies the completion of a schedule of reinforcement (variable interval, FR, and variable ratio) resulted in the presentation of a stimulus (bell and light) that signaled a point, and accumulated points were later exchanged for backup reinforcers. Reinforcement increased both the time riding the cycle and the rate of cycling. One advantage of using children as participants is that relatively inexpensive items (e.g., arts, crafts, and games) can be reinforcing to children. It is difficult to find effective inexpensive reinforcers for adults, particularly unmotivated college students. Bonus points toward a grade in class is usually effective to get students to volunteer for less strenuous, brief experiments such as completing questionnaires. However, in our experience, bonus points are not very effective in obtaining participants for research that requires rigorous physical exercise, especially for more than one or two sessions.

It is not surprising that money can have powerful effects on behavior. The contribution of this experiment was to show how money might be used to enhance the intensity and duration of exercise. A practical implication of this study is that response-contingent money may be used to motivate people to exercise within the context of a physical fitness program. Volunteers may give their trainer money at the beginning of each week or month. This money may be earned back daily by arranging contingencies similar to those used in the present experiment. Other contingencies such as variable-ratio schedules might generate even higher rates of exercising (e.g., Ferster & Skinner, 1957). This approach differs from those that employ contracts between an exerciser and a trainer (e.g., Wysocki et al., 1979). With contracts, a person may get their own money at the end of the month if they simply come to the gym an agreed-upon number of times or engage in a certain number of exercises. With response-contingent reinforcement, the amount of money a person collects can be directly proportional to their effort.

Playing background music throughout the session significantly increased the rate of cycling. However, the overall effect of music in the present study was rather weak: The effect size of auditory stimulus on cycling rate was only 0.19 compared to 0.66 for monetary incentive, music did not affect cycling time, and music did not enhance the effects of money. Further,

even though music significantly increased cycling rate overall, *a priori* dependent *t* tests showed that there was no significant difference in cycling rate between the control condition and the music condition. However, analysis of the percentage of change from the control condition did reveal that there was a significant increase of 4.5% under the music condition. Previous research has shown that playing background music often increases exercise performance, but that the effects are not always consistent (see Karageorghis & Terry, 1997 for review). Unfortunately, the variables responsible for these inconsistent findings have not been identified. The observation that many people prefer to exercise while listening to music suggests that background music should have reinforcing properties, and that these reinforcing properties might be revealed to be more powerful under appropriate experimental conditions. In the present study, music was played throughout the entire session. One suggestion for future research is to make periods of music contingent upon performance rather than playing music continuously in the background. For example, music could be turned on for 20 to 30 s following the completion of an FR schedule requirement (see Cohen et al., 2002) or the tempo of the music might be controlled by a participant's work output. The reason why contingent music was not studied in the present experiment was that the focus of the present study was on contingent money, and we wanted to determine if continuous background music, which is the normal mode of listening to music during exercise, could enhance the effects of monetary reinforcement. The present experiment used music that participants provided. Future research might also examine the possible interaction of different types of music (e.g., popular, classical, jazz) and monetary reinforcement.

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Steven L. Cohen is from the Department of Psychology and Linda M. LeMura is from the Department of Exercise Science. Linda LeMura is now the Dean of Arts and Sciences at Le Moyne College, Syracuse, NY.

This experiment was in partial fulfillment of the requirements for the degree of Master of Science in the Department of Exercise Science, Bloomsburg University, for Concetta Paradis.

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