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Coming From Behind: On the Effect of Psychological Momentum on Sport Performance

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The purpose of the present study was to test the predictions derived from 3 models of Psychological Momentum (PM) regarding the elusive PM–performance relationship. Participants competed in one of two 12-minute bogus bicycle races. They were randomly assigned to either a no-momentum race (i.e., tied) or a positive-momentum race (i.e., coming from behind to tie). Perceptions of PM and cycling performance were measured at 4 different points in time. Results from between- and within-subject analyses demonstrated that when participants lost the lead, their perceptions of PM decreased significantly. When participants regained the lead, their perceptions of PM increased significantly. Between- and within-subject analyses of variance also showed that experiencing PM led to increased performance. However, losing PM also led to performance enhancement, presumably through negative facilitation (Cornelius, Silva, Conroy, & Petersen, 1997). Results are discussed in light of models of PM, and avenues for future research are offered.

Key words: psychological momentum, performance, theory

Competitive sport provides an excellent arena for observing psychological momentum (Adler, 1981). The rapid shifts in scoring during a game can alter coaches', fans', and players' perceptions of momentum. For example, a basketball team would be said to be gaining momentum if it erased a 12-point deficit. Conversely, the team that was well-ahead but saw its lead evaporate would be said to be losing momentum. Gaining momentum is usually thought of as a factor that can enhance performance while losing momentum can be said to have the reverse effect (Taylor & Demick, 1994; Vallerand, Colavecchio, & Pelletier, 1988).

Three theoretical models have been proposed to explain how Psychological Momentum (PM) influences performance (Cornelius, Silva, Conroy, & Petersen,

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1997; Taylor & Demick, 1994; Vallerand et al., 1988). The first theoretical explanation examining this question is the Antecedents-Consequences Model of PM (Vallerand et al., 1988). One of the major contributions from this model is that Vallerand et al. noted that research attempting to examine the PM–performance relationship often fails to distinguish between PM's being the cause of successful performance and its being the effect of successful performance. Recognizing this problem, Vallerand and colleagues proposed a model that disentangles this confusion by specifying the antecedents and consequences of PM. According to Vallerand et al., PM refers to a perception that an actor is progressing towards his or her goal, thereby resulting in heightened levels of motivation, perceptions of control, optimism, energy, and synchronism. Failing to progress towards one's goal leads to a reduction in these same elements. The Antecedents-Consequences Model of PM postulates that situational antecedent variables can affect perceptions of PM. More precisely, situational antecedents or momentum starters (Adler & Adler, 1978), such as a steal or a dunk in basketball, may lead to enhanced PM perceptions and feelings. The Antecedents-Consequences Model of PM also postulates that PM can, in turn, influence performance. Experiencing enhanced perceptions of PM (i.e., positive momentum) can lead to an increase in performance, while experiencing a reduction in perceptions of PM (i.e., negative momentum) can be detrimental to performance.

However, Vallerand and colleagues (1988) have noted that whether PM will influence performance depends on personal and situational variables, as well as the nature of the task being performed. For instance, Vallerand et al. have suggested that certain personal variables such as sport competition anxiety and achievement motivation can provide limits within which PM can affect performance. For example, perceptions of PM may not lead to enhanced performance if an athlete is too anxious. In addition, Vallerand et al. have suggested that researchers need to carefully examine the nature of the task when considering the PM–performance relationship. Presumably, experiencing high levels of PM implies that an athlete is very aroused. Thus, based on Oxendine's (1970) work on the role of emotional arousal in sport performance, Vallerand and colleagues have reasoned that tasks requiring a great deal of arousal (e.g., riding a bicycle) should benefit most from PM, but those that necessitate low levels of arousal (e.g., free throw shooting in basketball) may not benefit from PM increases.

A second theoretical explanation of PM is the Multidimensional Model of Momentum proposed by Taylor and Demick (1994). According to this model, momentum is defined as "a positive or negative change in cognition, affect, physiology, and behavior caused by an event or series of events that will result in a commensurate shift in performance and competitive outcome" (Taylor & Demick, 1994, p. 54). The PM–performance relationship can best be explained by a momentum chain composed of six elements. The first element in this chain is a precipitating event that in turn leads to a change in cognition, affect, and physiology on the part of the athlete experiencing the event. Cognition, affect and physiological changes then influence the athlete's behavior, which in turn impacts on performance. Finally, Taylor and Demick (1994) suggest that one needs to take into account what they term "opponent factors" before arriving at the end of the chain (i.e., changes in the immediate outcome: winning or losing). For example, if an athlete catches up to a competitor in a race, the athlete should experience positive momentum (i.e., changes in cognition). This positive shift in cognition should influence the athlete's behavior (i.e., run faster). This change in behavior should in turn increase the athlete's performance. However, according to the Multidimensional Model of PM, a change in performance will lead to a change in the outcome of the competition only to the extent that the other competitor is experiencing negative momentum.

The last model of PM to be discussed is the Projected Performance Model (Cornelius et al., 1997). Unlike the two previous models, this model proposes that positive and negative momentum are labels used to evaluate performance, and that perceptions of PM have little influence on performance. According to this model, positive and negative perceptions of PM are the result of an extremely good or poor performance, respectively. Furthermore, this model suggests that perceptions of PM will be short-lived because there are several factors that can influence performance, including positive inhibition and negative facilitation. Positive inhibition occurs when a successful performance leads to negative change in subsequent performance. For example, a player could start to "coast" after he has caught up with an opponent and is now well ahead. Negative facilitation occurs following a negative performance. An athlete may then come out ready to play and be more energized to play than ever. Both positive inhibition and negative facilitation are believed to add to the complexity of studying PM.

Although it has been experimentally demonstrated that situational events can produce changes in PM (Cornelius et al, 1997; Miller & Weinberg, 1991; Shaw, Dzewaltowski, & McElroy, 1992; Silva, Cornelius, & Finch, 1992; Spink & Eisler, 1998; Vallerand et al., 1988), very little research has examined whether PM has a causal effect on performance. To the best of our knowledge, only three studies have experimentally assessed the effect of PM on performance. In a first study, Silva, Cornelius, and Finch (1992) had pairs of participants compete against each other using a novel motor-maze task. Results revealed that experiencing PM did not lead to performance enhancement compared to a negative momentum condition. In a second study, Shaw, Dzewaltowski, and McElroy (1992) also found no difference on free throw performance between participants experiencing repeated successes and participants experiencing repeated failures. In a third study, Cornelius et al. (1997) also failed to find a relationship between PM and free-throw shooting performance.

Although all three of the above studies demonstrated that repeated successes and failures can alter perceptions of PM, all three studies failed to demonstrate that PM has a causal effect on performance. However, the lack of a relationship between PM and performance in these studies could be attributed to methodological factors. First, all three of these studies used relatively fine motor skills (i.e., free throw and a maze task). These are precisely the type of tasks (i.e., complex and requiring a great deal of precision) for which Vallerand et al. (1988) noted that perceptions of PM may not translate into improved performance. As stated earlier, PM is associated with high levels of arousal. However, the type of tasks used in all three of these studies require relatively low levels of arousal to be performed well. It is thus not surprising that PM did not translate into improved performance in these studies. Second, Silva et al. (1992) used a novel motor-maze task. It is unlikely that such a task could be influenced by PM because participants were still learning how to do the task. PM should only influence performance when the task is well learned, that is, when participants are in the performance phase (Martens, 1969). Finally, Shaw et al. (1992) have acknowledged that they may have created time-outs in their study by having participants complete questionnaires between sets of free throws. A similar claim can also be made about the Cornelius et al. (1997) study. These temporal interruptions may have attenuated the effect of PM on performance (Duke & Corlett, 1992; Mace, Lalli, Shea, & Nevin, 1992; Salitsky, 1995). Thus, it is reasonable to state that no experimental study to date has tested the PM–performance relationship under conditions that are conducive to the appearance of this relationship.

The purpose of the present study was to examine the elusive PM–performance relationship. In this study, we examined in a laboratory setting if the precipitating event of coming from behind to tie an opponent in a bicycle race elicited changes in perceptions of PM, and if changes in perceptions of PM were related to changes in performance. Two reasons can be given to justify why we chose to test the elusive PM–performance relationship in the laboratory. First, past research has shown that coming from behind to win leads to changes in perceptions of PM (Vallerand et al., 1988). Second, using an experimental race permitted us to control for the behavior of the other competitor (Taylor & Demick, 1994). Thus, using an experimental race seemed ideal to test if PM affects performance. In line with all three models of PM, it was hypothesized that losing one's lead and coming from behind to tie should decrease and increase perceptions of PM, respectively. Furthermore, experiencing an increase in PM should lead to enhanced performance according to the Antecedents-Consequences Model of PM (Vallerand et al., 1988) and the Multidimensional Model of PM (Taylor & Demick, 1994). Finally, experiencing a loss of PM should not necessarily lead to a decrease in performance (Taylor & Demick, 1994; Vallerand et al., 1988). If one's opponent takes a lead, losses of PM may lead the competitor to alter his or her behavior or to experience negative facilitation (Cornelius et al., 1997) in response to this event and thus to pedal faster. This change in behavior should in turn increase the athlete's performance.

Method

Overview

Participants were asked to perform: (a) a VO_2max test on a cycle ergometer; (b) an accommodation bicycle ride; and (c) a solo 12-minute bicycle ride. Participants were then randomly assigned to one of two competitive conditions: a no-momentum (i.e., tied race) or a positive-momentum race. With the exception of the VO_2max test, all of the bicycle rides and races lasted 12 minutes. A Computrainer[1] (Model # 8000 by Racermate) was used to generate the competitive environment and to measure the power output of the participants. In both the no-momentum and momentum conditions, participants were led to believe that they were competing against a competitor who had produced the same mean power output as they had. When competing, participants were told to look at the television screen in front of them and to focus on the parameters provided by the Computrainer (i.e., who has the lead and how much time was remaining in the race). They were also told that their race would be videotaped and that they would see it afterwards. In fact, participants saw one of two prerecorded races during their race. During the race, participants were cued verbally every 2 minutes and 45 seconds in order to help them recall their perceptions of PM. Participants were also informed that a research assistant would turn off the television screen in front of them at the 11-minute mark (i.e., with one minute to go in the race) in order to be able to assess thoughts and feelings participants might have during the race without the impact of losing or winning. Following the race, participants were asked to sit in front of a television screen to review their race. The race was shown again and a graduate student in sport psychology stopped the tape at the 2:45, 5:30, 8:15, and 11-minute marks, respectively. Participants were asked to think how they felt during each of the four segments. Each time the videotape was stopped the participants completed the perception of momentum questionnaire.

Participants

Participants in this study were 7 male and 13 female physical education students ranging in age from 19 to 27 years, with a mean age of 21.8 years. Novice bicycle riders were chosen to perform this bicycle-riding task in order to control for potential individual differences that could have influenced our results. Participants received course credit for taking part in this experiment.

Instruments

A Computrainer, an electromechanical bicycle trainer, was used to measure the power output of the participants. In order to generate the competitive environment, we interfaced the Computrainer with an interactive software package that operates on the Nintendo Entertainment System. When one uses this software package, a participant's power output is translated directly onto a television screen via a Nintendo cyclist. Thus, participants using this apparatus can compare how well they are doing relative to their opponent.

Measures

Sport Achievement Orientation. The Sport Orientation Questionnaire (Gill & Deeter, 1988) was used to measure participants' competitiveness, win, and goal orientations. With the exception of the goal orientation (.67) subscale, coefficient alpha estimates of reliability for the present study were similar to those reported by Gill and Deeter (1988) for the competitiveness orientation (.84) and for the win orientation (.89) subscales.

Perceptions of Psychological Momentum. Perceptions of PM were assessed in a manner similar to that employed by Vallerand et al. (1988). Participants rated the extent to which they felt discouraged, confident, and energetic, as well as who they felt had momentum and the most control at four different points in time after their race. The five items were rated on a 7-point scale ranging from 1 (definitely the opponent) to 7 (definitely me) with a neutral midpoint 4 (neither me nor the opponent). Cronbach alpha values of .70, .84, .93, and .94 were obtained at times 1, 2, 3, and 4, respectively. Perceptions of PM were measured following each participants' competitive race. This methodology was selected based on the results of Blackburn and Hanrahan (1994). They compared various procedures to monitor athletes' thoughts and found that runners preferred a think-aloud procedure in combination with seeing a videotape of their performance when recalling thoughts about their run. In the present study, participants were shown their prerecorded race following their competition and were asked about their perceptions of momentum while watching their race at four different points in time. Although a think-aloud procedure was not used in the present study, participants were told, prior to competing, that they would be cued at four different points in time during their race by a research assistant and asked to remember how they felt during those four time periods. Despite its post-hoc nature, the major advantage of using this methodology is that the competition was in no way interrupted by time-outs that might affect the impact of PM on performance (Duke & Corlett, 1992; Mace, Lalli, Shea, & Nevin, 1992; Salitsky, 1995; Shaw et al., 1992).

Performance. Performance was measured with the power generated by the participants during the different bicycle races. The power generated by the participants during the solo 12-minute bicycle ride and the two experimental conditions was recorded every 5 seconds. An average power value was calculated to match the four time periods measured by the momentum questionnaire (see below). The average power values for time 1 to time 4 were divided by the participant's maximal power output. Peak power occurred during the last minute of the 12-minute solo bicycle ride. The mean peak power was 260.6 Watts.

Procedures

Participants were recruited in an exercise physiology class. The class instructor solicited the help of students by telling them that he was attempting to develop a 12-minute bicycle test analogous to the 12-minute run test (Cooper, 1968). Participants were also told that most exercise physiology tests are performed individually and that one of the goals of the present experiment was to examine if physiological responses would change depending on whether someone was tested individually or in competition against an opponent. The instructor then informed the participants about the demands of the experimental protocol and that if they decided to take part in the present experiment, they would be required to perform: (a) a VO_2max test; (b) a 12-minute accommodation bicycle ride; (c) a 12-minute solo bicycle ride; and (d) a 12-minute competitive race against an opponent from another university. Each of the components of the experiment was clearly explained (see below) to the participants.

Following these explanations, the instructor told the participants that, should they decide to volunteer for this experiment, they would have to complete some questionnaires. In order to explain this part of the experiment, a graduate student in sport psychology informed the class that one of his PhD assignments was to develop a questionnaire measuring thoughts and feelings during competition. Participants were then told that this experiment provided him with a unique opportunity to develop a preliminary questionnaire. After the graduate student finished his presentation, the instructor asked if anyone in the class had questions. Following the question period, participants who volunteered signed a consent form.

Participants who volunteered were asked to perform (a) a VO_2max test on a cycle ergometer; (b) an accommodation bicycle ride; and (c) a solo 12-minute bicycle ride. In addition, participants were randomly assigned to one of two competitive conditions: a no-momentum race (i.e., tied race) or a positive-momentum race (i.e., coming from behind to tie the race). The competitive races were held in the following laboratory set-up. There were four rooms in the laboratory: two competitive rooms separated by a small control room and a large room adjacent to the three experimental rooms. Both competitive rooms contained a one-way mirror that permitted the experimenter seated in the control room to view both competitive

rooms. Also, bogus wiring was passed through the ceiling in order to give the impression that the main competitive room and the control room were linked. Experimental data was recorded using a videotape machine and a television set found in the small control room. The main competitive room contained a new 12-speed bicycle, a Computrainer, a television set, a fan, and a videotape machine mounted on a small table. The other competitive room contained the same equipment with the exception of the 12-speed bicycle and the Computrainer. Finally, in the room adjacent to the three experimental rooms, schedules were posted on a large billboard and the names of the two competing universities were placed on the doors of both competitive rooms. The various bicycle rides were performed according to the following schedule. Participants were allowed to perform both the VO_2max test on a cycle ergometer and the accommodation bicycle race on the same day. As for the solo bicycle ride and the competitive race, they were performed on different days.

VO_2max Testing. Metabolic data were continuously monitored using a SensorMedics system. Heart rate was recorded with a Polar Sport Tester. The temperature in the laboratory was controlled between 20 and 23 Celsius. The VO_2max test began at a power output of 30 watts and increased by 30 watts every minute until volitional exhaustion. The peak VO_2 in a one-minute period was used as the VO_2max. Three criteria were used to verify that VO_2max was obtained: (1) a plateau in VO_2 with an increase <1.5 ml/kg min when workload was increased; (2) a respiratory exchange ratio >1.10; and (3) a ventilatory equivalent > 30 L of air/L of oxygen. All of the subjects achieved at least 2 of the 3 criteria (American College of Sport Medecine, 1995). The VO_2max averaged 2.97 L/min or 41.7 ml/kg min, while the mean heart rate max was 188 bpm.

Accommodation Bicycle Ride. The purpose of this test was to sensitize the participants to the bicycle, the competitive environment, and the Computrainer. Two research assistants showed participants the three experimental rooms and explained how the race would be performed. Participants were told that competitors would ride in their assigned rooms and that the experimenter found in the small control room would cue the competitors when to start. Following these instructions, the participants were taken to the main experimental room where seating position on the bicycle was adjusted according to the height of the participant. Next, participants pedaled the 12-speed bicycle to select a gear that would be used throughout the 12-minute solo bicycle ride and the 12-minute bicycle race. Participants were instructed to select a gear with which they could generate the greatest power possible without "dying" before the end of their race.

While the participants pedaled, a research assistant explained how the Computrainer worked. Participants were asked to focus on a television screen in front of them. They were then told that they were represented by one of two Nintendo cycling figures. It was further explained to participants that their lead or their opponent's lead (in feet) and the race time would be indicated on the screen. Furthermore, the research assistant stressed that they would need to concentrate on these elements during their competitive race. The remaining parameters (i.e., power, distance, speed) produced by the Computrainer were hidden from the participants. Since the Computrainer needed to be calibrated at a fixed resistance level every time someone rode the bicycle, participants sprinted on the bicycle in order to calibrate the bicycle. Participants then rode the bicycle for 12 minutes at their selected gear. The gear and the seat position chosen by the participants were recorded for future tests.

Finally, following the accommodation trial, participants completed the Sport Orientation Questionnaire (Gill & Deeter, 1988) and the synonym-generation task. The synonym-generation task involved having participants generate synonyms of feelings and thoughts they may have experienced in past competitions. Results from this task were never used. This bogus task was used to justify the presence of the graduate student in sport psychology.

Solo 12-Minute Bicycle Ride. Participants performed an individual bicycle ride for 12 minutes. The goal of this test was to generate the greatest amount of power possible for 12 minutes. Participants rode at their selected gear and were only given feedback with respect to how much time they had been riding their bicycle. Metabolic data were collected throughout this ride. VO_2, heart rate, and power were averaged for each minute of the test.

Competitive Races. A research assistant escorted participants from the cafeteria to the laboratory. This procedure was used to hide the fact that no real competitor was in the other competitive room. Upon arriving in the laboratory, the research assistant checked with another research assistant to see if the bogus competitor had arrived. In every case, the research assistant received a positive response to the query and proceeded to bring the participant into the main competitive room, closing the door after entering the room. The door to the bogus competitor's room was already closed.

In both the no-momentum and momentum conditions, participants were led to believe that they were competing against a competitor who had a VO_2max and mean power output similar to their own. Participants were also told that they were competing in separate rooms in order to control for potential biases participants may have about the competition. Participants were told that if they saw what appeared to be a stronger and taller competitor that they might feel threatened in some way. Another reason given to participants to justify competing in separate rooms was to avoid any form of communication between the two competing parties.

After participants entered the room, they warmed up for 3 minutes, and the Computrainer was calibrated as described above. While participants were warming up, they were given these final instructions: First, participants were told to look at the television screen in front of them and to focus on the parameters provided by the Computrainer (i.e., who had the lead and the time remaining in the race). Second, they were also told that their race would be videotaped and that they would see it afterwards. In fact, participants were shown one of two prerecorded races during their race. Third, participants were also reminded that they would be cued verbally every 2 minutes and 45 seconds in order to help them recall their feelings. Finally, participants were informed that a research assistant would turn off the television screen in front of them at the 11-minute mark (i.e., with one minute to go in the race). It was explained to participants that the television screen needed to be turned off at that time because the graduate student in sport psychology wanted to avoid having the outcome (i.e., winning or losing) affect thoughts and feelings participants might have during the race. Furthermore, participants were instructed to keep pedaling until the end of the race. When the television screen was turned off, a research assistant cued the participants with respect to how much time was left before the end of the race in 15-second increments. In the last 15 seconds, feedback was given every 5 seconds, and the last 5 seconds were counted down from one to zero.

Just before the start of the race, one of the two research assistants left the room to check if the bogus competitor was ready. The research assistant returned shortly after to confirm that the other competitor was ready to start and took a seat in front of a videotape machine situated to the right of the participant. A research assistant in the control room knocked on the one-way mirror of both competitive rooms to indicate the beginning of the race, then recorded the power output throughout the 12-minute race. In the competitive room, the research assistant started the prerecorded race.

Participants saw one of two prerecorded races. In the no-momentum condition, participants saw a race where both competitors were tied for the duration of the race. Slight lead shifts were included in the tape to make the race more realistic. The lead jockeyed back and forth and the biggest lead held at any point in time by a competitor was about 8 feet. When the television was turned off, participants saw that they were tied with their bogus competitor (i.e., no one had the lead). In the momentum condition, participants saw a race where both competitors were tied for the first 5 minutes and 30 seconds. Once again, slight lead changes were included to make the race appear realistic. After the 5:30 mark, participants started to lose the lead until the 8:15 mark of the race. At that point in time, participants found themselves to be down in the race by 40 feet. From the 8:15 mark to the 9-minute mark, slight fluctuations in the bogus opponent's lead were created, and from the 9-minute mark to the 11-minute mark, participants gradually came from behind to tie their opponent at the 11-minute mark. Thus, as in the Vallerand et al. (1988) study, perceptions of PM were induced by coming from behind to tie one's opponent.

Following the race, participants cooled down for about 5 minutes and were escorted to a viewing room situated outside of the laboratory by one of the research assistants. Upon arriving at the viewing room, the research assistant handed the tape of the prerecorded race to the graduate student in sport psychology. Participants were asked to sit in front of the television screen to review their race. Participants were also asked if a research assistant had cued them at every 2 minutes and 45 seconds. All of the participants confirmed that they had been cued four times. The race was shown again and the graduate student in sport psychology stopped the tape at the 2:45, 5:30, 8:15, and 11-minute mark, respectively. Participants were asked to think how they felt during each of the four segments. Every time the videotape was stopped, the participants completed the perceptions of momentum questionnaire.

Results

Preliminary Analyses

A first series of analyses assessed whether participants in the two experimental conditions differed on competitiveness orientation, win orientation, goal orientation, VO_2max, power generated in the 12-minute solo bicycle ride, and maximal power output. Results indicated no significant differences between the two experimental conditions on all of the variables listed above (all t values < 1.0). Thus, these analyses revealed that both groups were quite similar.

Main Findings

In the following analyses, the results of Time 1 (first 2 minutes and 45 seconds of each race) for PM and performance were removed from the analyses because the power values generated during this time period were artificially inflated due to the fact that participants were starting their race and needed to adjust to the Computrainer. Thus, Time 2 was used as a baseline.

Perceptions of Psychological Momentum. A 2 × 3 (Condition × Time) repeated measures ANOVA was performed on the PM scale. The main effect for condition, $F(1,18) = .59, p > .05$, was not significant. However, the main effect for time, $F(2, 36) = 26.07, p < .001$, as well as the Condition × Time interaction, $F(2, 36) = 16.13, p < .001$, were significant. Planned comparisons were then performed in order to examine if participants in the momentum condition differed in their perceptions of PM from participants in the no-momentum condition at each time level. Results indicated that both conditions, $F(1, 18) = .36, p > .05$, did not differ at Time 2. However, both conditions, $F(1, 18) = 11.08, p < .01$, did differ at Time 3. Participants in the momentum condition who were losing their lead perceived less PM ($M = 2.6$) than participants in the no-momentum condition ($M = 4.4$). Finally, both conditions, $F(1, 18) = 11.65$, $p < .01$, also differed at Time 4. Participants in the momentum condition who were regaining the lead perceived more PM ($M = 6.1$) than participants in the tied condition ($M = 4.4$). Means and standard deviations of PM perceptions are presented in Table 1.

Separate within-group analyses were also performed in order to explore if the experimental conditions created different perceptions of PM between adjacent time periods. Figure 1 illustrates that participants in the no-momentum condition, $F(2, 18) = 1.02, p > .05$, did not show any change in their perceptions of PM across time periods. Participants in the momentum condition, $F(2, 18) = 33.98, p < .01$, did show changes in their perceptions of PM. Planned comparisons revealed that perceptions of momentum significantly decreased from Time 2 ($M = 4.1$) to Time 3 ($M = 2.6$). Furthermore, results indicated that participants in this condition significantly increased their perceptions of momentum from Time 2 ($M = 4.1$) to Time 4 ($M = 6.1$), and from Time 3 ($M = 2.6$) to Time 4 ($M = 6.1$). In short, when participants lost and regained the lead, they showed a significant decrease and increase in their perceptions of PM, respectively. On the other hand, participants in the no-momentum condition did not show any significant changes in their perceptions of PM.

Table 1 Means and Standard Deviations for Perceptions of PM and Performance (Power)

	Time 1 (0:00-2:45)		Time 2 (2:45-5:30)		Time 3 (5:30-8:15)		Time 4 (8:15-11:00)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
No-momentum condition								
Perceptions of PM	4.2	0.6	4.4	1.0	4.4	0.7	4.8	0.7
Performance (% of peak power)	82.6	12.5	73.6	8.2	73.9	9.2	77.6	6.9
Momentum condition								
Perceptions of PM	3.9	1.0	4.1	1.0	2.6	1.6	6.1	1.0
Performance (% of peak power)	82.7	18.0	73.4	12.1	77.7	7.8	85.1	4.9

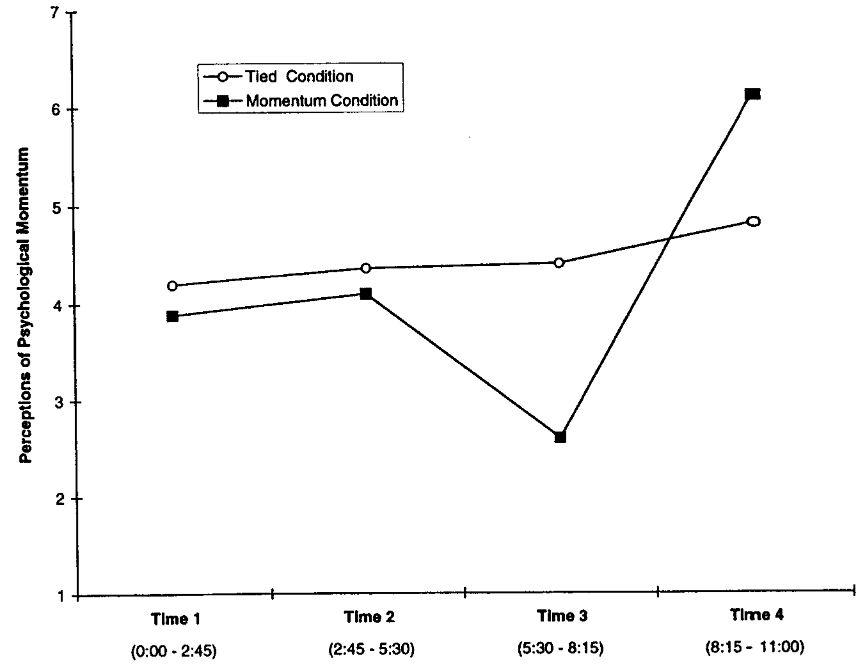

Figure 1 — Changes in perceptions of Psychological Momentum across time as a function of coming from behind to tie (momentum condition) or being tied (no-momentum condition).

Performance. A 2 × 3 (Condition × Time) repeated measures ANOVA was also performed on performance. The main effect for condition, $F(1, 18) = 1.28, p > .05$, was not significant. However, the main effect for time, $F(2, 36) = 12.17, p < .001$ was significant. Finally, a marginally significant Condition × Time interaction, $F(2, 36) = 2.74, p < .08$, was revealed. Although this effect did not reach conventional significance, in line with Keppel (1982), planned comparisons were performed in order to examine if participants in the no-momentum condition differed on performance from participants in the momentum condition at each time level. Results indicated that neither condition, $F(1, 18) = .01, p > .05$, differed at Time 2. Results also indicated that neither condition, $F(1, 18) = .95, p > .05$, differed at Time 3. However, both conditions, $F(1, 18) = 7.84, p < .05$, differed at Time 4. Participants in the momentum condition (see Table 1) who were regaining the lead performed better (85.1% of peak power) than participants in the no-momentum condition (77.6% of peak power).

Separate within-group analyses were also performed in order to explore if the experimental conditions created different levels of performance between adjacent time periods. Figure 2 illustrates power output relative to the peak power[2] produced in minute 12 of the solo bike ride. Participants in the no-momentum condition, $F(2, 18) = 1.90, p > .05$, did not show any change in their performance across each of the time periods. However, participants in the momentum condition, $F(2, 18) = 12.74, p < .01$, did show changes in their performance. Planned comparisons revealed that participants' performance significantly increased throughout the race with the power increasing from 73.4 at Time 2 to 77.7 at Time 3 to

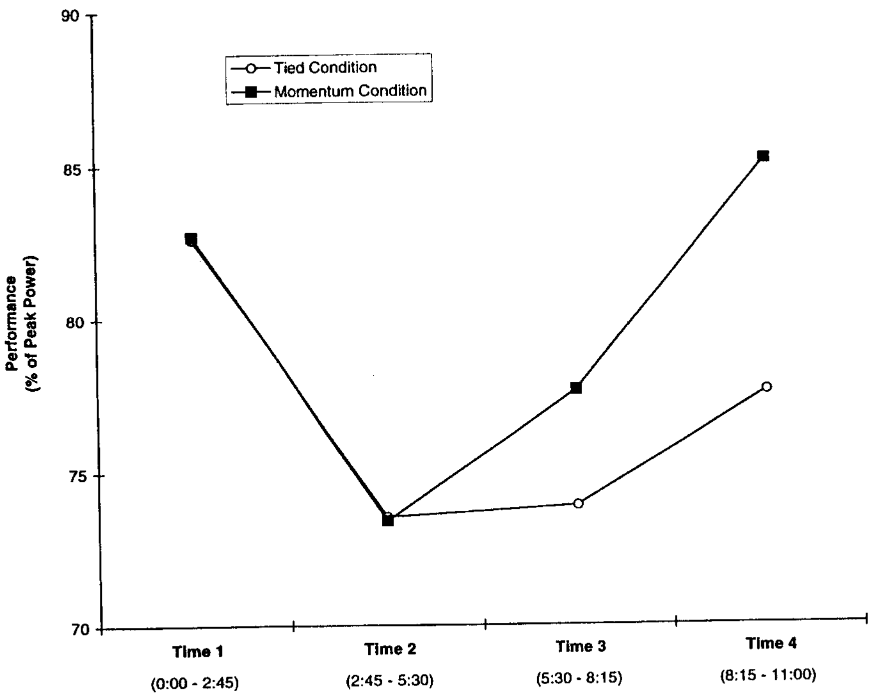

Figure 2 — Changes in performance across time as a function of coming from behind to tie (momentum condition) or being tied (no-momentum condition).

85.1% at Time 4. In short, when participants lost their lead they pedaled faster, and when they regained their lead, they generated an even greater power output than when they were tied with their opponent or when they were losing by 40 feet. On the other hand, participants in the no-momentum condition did not show any significant variation in performance across the different time periods.

Correlations Between Psychological Perceptions of Momentum and Performance. In order to ascertain the relationship between perceptions of PM and performance, Pearson correlations were calculated for each of the three time periods. Results indicated a nonsignificant negative relationship, r (20) = –.35, $p > .05$, between PM and performance at Time 2. A similar relationship, r (20) = –22, $p > .05$, was also found at Time 3. Both these results suggest that the more a competitor experienced negative PM, the faster the participant pedaled. Results also indicated a nonsignificant positive relationship, r (20) = .33, $p > .05$, between PM and performance at Time 4, suggesting that the more a competitor experienced positive PM, the faster the participant pedaled. To clarify further the relationship between PM and performance, the key item of "who had the momentum" at Time 2, Time 3, and Time 4 was correlated with performance. When these correlational analyses were performed, the relationship, r (20) = –.33, $p > .05$, between PM and performance at Time 2 remained nonsignificant. However, the relationship, r (20) = –.43, $p < .06$ between PM and performance at Time 3 and the relationship r (20) = .44, $p < .06$, between PM and performance at Time 4 became marginally significant. On the whole, these results confirm the idea that PM can influence performance. When

participants experienced a loss of momentum (Time 3), they subsequently increased their performance in order to catch up to their opponent. Finally, when participants experienced heightened levels of PM (Time 4), they also subsequently augmented their performance.

Discussion

The purpose of the present study was to test the predictions from three models of Psychological Momentum (PM) with respect to the elusive PM–performance relationship. Based on the Antecedents-Consequences Model of PM (Vallerand et al., 1988), the Multidimensional Model of PM (Taylor & Demick, 1994), and the Projected Model of Performance (Cornelius et al., 1997), it was predicted that participants in the momentum condition should perceive a loss of PM when their opponent took a 40-foot lead and an increase in PM when they regained the lead in comparison to participants in the tied condition. Furthermore, in line with all three PM models, it was predicted that experiencing a loss of PM should lead to a change in behavior on the part of the competitor in the race. If one's opponent takes a lead, the competitor should alter his or her behavior or experience negative facilitation (Cornelius et al., 1997) in response to this event and pedal faster. This change in behavior should in turn increase the athlete's performance. Finally, experiencing an increase in PM should also lead to enhanced performance according to the Antecedents-Consequences Model of PM (Vallerand et al., 1988) and the Multidimensional Model of PM (Taylor & Demick, 1994). Results of this study provided strong support for all three hypotheses.

First, we examined the effect of losing and regaining one's lead on perceptions of PM. In line with all three models of PM reviewed herein, the results of this study demonstrated that when participants lost the lead, they showed a decrease in their perceptions of PM. Results also showed that when participants regained their lead, they showed an increase in their perceptions of PM. This pattern of results was confirmed in both between- and within-subject analyses. This result corroborates previous findings (Miller & Weinberg, 1991; Shaw, Dzewaltowski, & McElroy, 1992; Silva, Cornelius, & Finch, 1992; Spink & Eisler, 1998; Vallerand et al., 1988) and lends support to the hypothesis that a situational variable such as coming from behind can have a profound effect on perceptions of PM.

Second, the present study also provided support for the Antecedents-Consequences Model of PM (Vallerand et al., 1988) and the Multidimensional Model of PM (Taylor & Demick, 1994) by demonstrating that when participants' perceptions of PM were at their highest, they generated their highest level of performance. This finding represents the first substantive empirical support for the prediction that enhanced PM leads to better performance. This pattern of results was confirmed by both between- and within-subject analyses of variance and by way of a correlational analysis. The present results also confirmed Vallerand and colleagues' suggestion that perceptions of PM are beneficial for tasks that require a great deal of effort. It should also be noted that performance was in no way interrupted by time-outs in the present study (on this issue, see Shaw et al., 1992). Competing freely without interruption is another factor that may have promoted the link between PM and performance.

A third finding of interest deals with the effect of negative PM on performance. Contrary to popular belief, experiencing negative PM was not detrimental to performance in the present study. Results indicated that when participants' perceptions of PM were at their lowest, they pedaled faster than when they were tied with their opponent. This result is in line with all three PM models and supports the idea that researchers need to take into account how an athlete reacts to the behavior of an opponent when studying the elusive momentum-performance relationship. In the context of this study, one can argue that participants pedaled faster when they started to lose their lead in order to regain control over the race. However, it is important to note that a competitor will attempt to regain control over the race only up to a certain point. With prolonged failure (i.e., inability to reclaim the lead), Wortman and Brehm (1975) suggest that reactance motivation will decrease and competitors should eventually lose their motivation and become amotivated (Deci & Ryan, 1985). Performance would then deteriorate. In the present study, competitors lost their lead only for a relatively short period of time. Thus, they never fell into a state of amotivation. This might explain why negative PM did not undermine performance. Had the loss of PM lasted for a longer period of time, it is likely that an acute loss of performance might have been observed. Future research should test this hypothesis.

In closing, four important limitations of the present study need to be acknowledged. First, we did not create a condition in which participants took an early lead and then lost their lead to their opponent. One cannot rule out the possibility of an order effect influencing our results. Taking an early lead could lead to positive facilitation, that is, a competitor could start to "coast" because he or she is now well ahead (Cornelius et al., 1997). Future studies need to evaluate this possibility. A second limitation is that we created a situation in which participants were led to believe that they were competing against an opponent with a similar fitness level. Implicitly, we created a situation in which the participants believed that their opponent was of similar ability. Future research may wish to manipulate the level of ability of the opponent by telling participants that they are competing against an opponent who is not as fit or fitter than them in order to verify the impact of this variable on the PM–performance relationship. Third, participants who took part in this experiment were novice cyclists. A variety of authors have argued that expertise is a key personal variable that might moderate the PM–performance relationship (Taylor & Demick, 1994; Vallerand et al., 1988). Highly experienced competitors have schemas that help them process sport-related information more efficiently. Future studies could use the present task in order to examine the PM–performance relationship of both expert and novice athletes. Finally, the results of this study tend to suggest that the Antecedents–Consequences Model of PM (Vallerand et al., 1988) and the Multidimensional Model of PM (Taylor & Demick, 1994) are better explanations of the elusive momentum-performance than the Projected Model of Performance (Cornelius et al., 1997), which posits that PM and actual performance are unrelated. However, it is important to note that we measured PM after the race. Although a great deal of care was taken to ensure that participants would remember how they felt at various precise moments, perceptions of PM could have been the result of performance, thus supporting the Projected Model of Performance (Cornelius et al., 1997). Future studies need to evaluate PM while a participant is performing in a competition. Researchers could replicate this study and use the key item "Who has the momentum" while a competitor is racing in order to better evaluate if PM is an antecedent of performance.

In sum, results from this study confirmed that a situational variable such as coming from behind can have a profound effect on perceptions of PM. More important, the results of this study provided the first experimental evidence to support the link between perceptions of PM and performance as proposed by the Antecedent-Consequences Model of PM model (Vallerand et al., 1988) and the Multidimensional Model of Momentum (Taylor & Demick, 1994). On the whole, experiencing PM can facilitate performance for a task that requires a great deal of effort. However, the loss of PM, for a short duration, can also influence performance through negative facilitation (Cornelius et al., 1997). Further research is needed to understand the intricacies of the PM–performance relationship.

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Notes

[1]For more information concerning the Computrainer, we refer the reader to the following web site: racermate@aol.com.

[2]Peak power was equivalent to 116% of VO_2max (American College of Sport Medicine, 1995). This value clearly indicates that participants had entered the anaerobic stage. Thus, this result indicates that participants expended a great deal of effort while performing the bicycle race.

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