The Dynamics of Psychological Momentum in Sport: The Role of Ongoing History of Performance Patterns

Christophe Gernigon,¹ Walid Briki,¹ and Katie Eykens²
¹Montpellier 1 University; ²Catholic University of Leuven

Borrowing the dynamical systems perspective, two studies aimed to examine the potential properties of nonlinearity and history dependence of psychological momentum. Male regional-level table tennis players were asked to empathize with players in a very important contest by watching two video scenarios of a table tennis game in two separate sessions. The videos presented two inverted scenarios in which score gaps gradually increased or decreased. Competitive anxiety, self-confidence (Study 1), and goal involvement states (Study 2) were measured before each point. Cognitive and somatic anxieties decreased linearly during the increasing scenario, but increased nonlinearly in the decreasing scenario. Mastery-avoidance goals decreased nonlinearly in the increasing scenario, increased nonlinearly in the decreasing scenario, and displayed a negative hysteresis pattern. These findings offer new insights into the dynamics of psychological momentum and suggest new avenues of research.

Keywords: achievement goals, anxiety, dynamical systems, negative hysteresis, self-confidence

Momentum was first defined as “a state of dynamic intensity marked by an elevated or depressed rate in motion, grace, and success” (Adler, 1981, p. 29). Regardless of whether momentum has significant (Perreault, Vallerand, Montgomery, & Provencher, 1998) or little (e.g., Stanimirovic & Hanrahan, 2004) influence on performance, every conceptualization of this phenomenon stresses that momentum includes a number of psychological features that shift according to how individuals progress or regress in relation to the goal to be reached. Therefore, what psychologists label psychological momentum (PM) has been of central interest in some recent models of momentum. Vallerand and his colleagues (Perreault et al., 1998; Vallerand, Colavecchio, & Pelletier, 1988) proposed an antecedents-consequences model in which PM is defined as the “perception that the actor is
progressing toward his/her goal. . . . [S]uch a perception of progression toward the
goal is associated with heightened levels of motivation and enhanced perceptions
of control, confidence, optimism, energy and synchronism” (Vallerand et al., 1988,
p. 94). Similarly, considering PM at the core of a causal chain unfolding from some
precipitating events to their effects on performance, Taylor and Demick (1994)
proposed a multidimensional model in which PM is defined as a “positive or nega-
tive change in cognition, physiology, affect, and behavior caused by a precipitating
event or series of events that will result in a shift in performance” (p. 51).

Focusing less on the impact of PM on performance, Markman and Guenther
(2007) have recently attempted to account for the social perception of PM through an
analogy with the variables of mass and velocity in Newtonian physics. To test their
assumptions, Markman and Guenther conducted a series of experiments based on
the viewing of selected sport contest scenarios or the reading of scenarios of daily
life task completions. First, these authors found that precipitating events affect the
positive velocity that characterizes the evolution toward a goal, thus enabling the
perception of positive momentum. This role of velocity and of its variation (i.e.,
acceleration) resembles notions of acceleration and quasi-acceleration functions that
have been respectively theorized by Carver and Scheier (1990) and by Hsee, Salovey,
and Abelson (1994). According to these authors, changes in affect are determined
by sensed changes in velocity (i.e., acceleration or deceleration). Second, Markman
and Guenther showed that velocity can combine multiplicatively with the strength
of contextual variables such as the value, the immediacy, or the importance of the
situation, whereby these contextual variables would play the role of the mass in
physics. Third, Markman and Guenther found that PM was perceived to be either
an impetus whose effects persist across successive situations or an impetus that
is hard to regain, when accidentally stopped, thus suggesting an analogy between
PM and the physical notion of inertia.

Establishing an analogy between PM and physical laws is a good way to
illustrate how PM is a highly dynamical process. However, we would like to carry
the analogy to the point of examining whether the dynamical properties of PM
can be considered within the dynamical systems theory. A dynamical system is a
set of elements whose complex interactions yield the emergence of some typical
properties, which include nonstationarity, nonlinearity, history dependence, and
hysteresis. These few features do not exhaust all the properties of dynamical sys-
tems (e.g., see Nowak and Vallacher, 1998), but our focus on them is justified by
their similarities with those of momentum phenomena.

The interactions among the elements of a dynamical system are so complex
that any causal mechanism in isolation is inadequate to characterize the resultant
phenomenon in all its complexity (Nowak & Vallacher, 1998). Concerning PM,
qualitative data collected from sport practitioners revealed a great number of precip-
itating events that are perceived as potential PM triggers (Jones & Harwood,
2008; Taylor & Demick, 1994). Taylor and Demick (1994) classed these PM
determinants as pertaining to internal (e.g., complacency, psychological states,
fatigue), environmental (e.g., scoring configurations, dramatic actions, opponent’s
behaviors, referees decisions), and social (e.g., team cohesion, staff influences,
crowd influences) factors. Continuing Markman and Guenther’s (2007) velocity
× mass perspective, evidence for complexity of PM determinants can be found by
considering the innumerable interactions among these internal, environmental, and
social precipitating events. The consistent or contradictory interplay among these different kinds of determinants leads to the perception of PM or not, depending on what sources of information are most salient for an individual in a given situation and a given social context (Vallerand et al., 1988).

By definition, the states of a dynamical system undergo changes in time (e.g., Nowak & Vallacher, 1998). Nonstationarity of PM is unambiguously reflected by the etymology of the Latin word *momentum* (movement, moving power). Moreover, repeated or continuous measures–designed research has yielded that a number of psychological variables—such as the perception of PM (Kerick, Iso-Ahola, & Hatfield, 2000; Perreault et al., 1998; Shaw, Dzewaltowski, & McElroy, 1992; Stanimirovic, & Hanrahan, 2004), affects (Hsee et al., 1994, experiment 2; Lawrence, Carver, & Scheier, 2002; Stanimirovic, & Hanrahan, 2004), self-efficacy (Shaw et al., 1992), and team efficacy (Stanimirovic & Hanrahan, 2004)—vary significantly while success or failure experiences or hypothetical scenarios unfold.

The relationships between the elements of a dynamical system and its global behavior (called collective variable, or order parameter) are nonlinear in nature, since the states of the system can display qualitatively different patterns that may succeed one another with abrupt changes. Thus, a great variation in the value of one or several elements can lead to no change in the phenomenon in question (when the system is in a stable state of equilibrium), whereas a tiny variation in the value of one element of the system can lead to a catastrophic change (when the system is in an unstable state of equilibrium). Although Adler (1981) considered that PM may develop either suddenly (explosive momentum) or gradually (placid momentum), PM is most often associated with the notion of abrupt change (Taylor & Demick, 1994). Theoretical arguments in favor of the nonlinearity of PM fluctuations can be found in both Carver and Scheier’s (1990) control process theory of affects and Hsee et al.’s (1994) quasi-acceleration function. According to these models, the more abrupt the change in the rate of move toward a goal, the greater and more suddenly the affect changes, like a rush of exhilaration or sinking feeling. Empirical support for this tenet has been provided by Hsee et al. (1994, experiment 2).

One of the main determinants of the state of a dynamical system at a given time is its own history, or in other words, its own states at previous times. Strikingly, PM’s dependence on history is another major tenet in every conceptualization of the phenomenon. For this reason, all experimental studies of PM manipulate feedback or performance scenarios. Vallerand et al. (1988) refer to Abelson’s (1981) concept of script when discussing the antecedents from which PM emerges. According to Abelson, scripts are cognitive structures that describe sequences of events in specific social contexts and whose activation organizes the comprehension of situations.

A consequence of both nonlinearity and sensitivity to history is that the course of events makes the behavior of the system hardly reversible. Therefore, once a given scenario has brought about a change in the state of the system, there is resistance to returning to the former state under the effect of a reversed scenario, and thus recovery is delayed. This path-dependent lag, which is well known in physics, is called hysteresis. To date, no research has been conducted to test hysteresis effects with respect to PM. The findings closest to the notion of hysteresis have been obtained by Markman and Guenther (2007), who showed that on the one hand, PM is perceived as persisting across successive situations once it is triggered, but on the other hand, PM is perceived as difficult or impossible to recover if stopped.
In spite of the apparent similarities between properties of PM and those of dynamical systems, PM cannot be viewed as a dynamical phenomenon in perfect accordance with the theory of dynamical systems. In every field, evidence of properties of dynamical systems, such as nonlinearity, history dependence, hysteresis, and others beyond the scope of the present research (e.g., see Nowak and Vallacher, 1998), needs to be shown based on the classical research paradigms of the dynamical approach. Social psychology may not be an exception (Beek, Verschoor, & Kelso, 1997). According to Haken, Kelso, and Bunz (1985), the global behavior of any dynamical phenomenon (i.e., the order parameter) needs to be observed under the effect of gradual variations—increasing and decreasing—of a variable external to the system (called the control parameter).

The present research is an exploratory, initial attempt to see whether there are nonlinear and history effects in PM when respecting the methodological constraints of the dynamical approach. Two studies were conducted based on the observation of sport-specific scenarios. Based on consistent previous findings showing that either observed (e.g., Markman & Guenther, 2007; Vallerand et al., 1988) or experienced (e.g., Kerick et al., 2000; Perreault et al., 1998; Shaw et al., 1992; Silva, Cornelius, & Finch, 1992; Stanimirovic, & Hanrahan, 2004) scenarios of performance can influence PM, the scenarios that were used presented increasing versus decreasing score configurations. Increasing and decreasing scorings were assumed to generate the perceptions of moving toward or away from the desired outcome (winning) that are at the origin of positive or negative PM, respectively (Vallerand et al., 1988). Consistent with previous models of PM, we view this phenomenon as a dynamics that can apply to a number of domains, such as cognition, affect, motivation, physiology, and behavior (e.g., Adler, 1981; Taylor & Demick, 1994). Hence, several kinds of dependent variables can account for the occurrence of PM, provided they display dynamical patterns while the manipulated scenarios of scoring unfold. In Study 1, the dynamics of competitive anxiety and self-confidence was examined, since these variables are acknowledged as major psychological determinants of sport performance (Gernigon & Delloye, 2003; Woodman & Hardy, 2003). In Study 2, the dynamics of approach and avoidance goals was investigated because these categories of goals relate to constructs that are close to self-confidence and anxiety in achievement contexts (e.g., Conroy, Elliot, & Hofer, 2003; Elliot & Church, 1997; Elliot & McGregor, 2001).

Study 1

Markman and Guenther’s (2007) mass × velocity model predicts that PM develops more when the situation in which a person is progressing toward a goal is important to him or her. According to Lazarus and Folkman (1984), appraising a situation as being of great importance can lead the person to consider that situation either as a challenge or a threat, depending on whether he or she is confident or not about his or her resources to cope with it. If not confident, the person will develop a stress syndrome in the form of anxiety and maladaptive physiological and behavioral responses. Specific achievement situations such as sport contests sometimes represent situations of great significance for the actors, wherein self-confidence and anxiety have been found to significantly contribute to determining performance
and outcomes, particularly in high-standard competitions (Woodman & Hardy, 2003). Martens, Vealey, and Burton (1990) have proposed a conceptualization of competitive anxiety as stemming from a perception of threat, which is a result of a multiplicative function of perceived importance and uncertainty of outcome.

Although research into goal attainment velocity (Hsee & Abelson, 1991; Hsee et al., 1994; Lawrence et al., 2002) and PM (Kerick et al., 2000; Stanimirovic & Hanrahan, 2004) mainly addressed affects, no empirical study has yet focused on anxiety as a specific feature of PM. However, the recognized link between competitive anxiety and performance (Woodman & Hardy, 2003) and the fact that athletes report feeling threatened when experiencing negative momentum (Jones & Harwood, 2008) should draw researchers’ attention to the possibility that anxiety might be a psychological feature of momentum. Moreover, competitive anxiety has been found to undergo rapid and important variations during contests. Indeed, perceptions of bodily symptoms of competitive anxiety—namely, somatic anxiety— increase as a competition approaches and then fade away once the athlete begins to perform, whereas negative concerns about performance—namely, cognitive anxiety—vary from moment to moment according to the ongoing expectations of success and perceived situational threat (Martens et al., 1990). Using a procedure adapted from Vallacher and colleagues’ mouse paradigm (e.g., Vallacher, Nowak, Froehlich, & Rockloff, 2002), which consisted in moving a computer mouse to retrospectively express on a computer screen one’s moment-to-moment level of cognitive anxiety, Gernigon, Yvelin, Delignières, Ninot, and d’Arripe-Longueville (2002) found that cognitive anxiety undergoes abrupt changes during some very short periods of sport contests such as time-outs.

Self-confidence is another important performance-related psychological variable (Gernigon & Delloye, 2003; Woodman & Hardy, 2003) that is cited by actors who have experienced momentum (Jones & Harwood, 2008; Taylor & Demick, 1994). In a study based on the manipulation of repeated success or repeated failure in basketball tasks, Shaw et al. (1992) found that participants experiencing repeated success became more and more confident over time. Based on Bandura’s (1997) concept of collective efficacy, Stanimirovic and Hanrahan (2004) addressed team-efficacy beliefs, that is, the degree of confidence individuals have in their team’s ability to perform important game competencies. These authors found that manipulated repeated successes or failures in volleyball trials entailed increases or decreases, respectively, in team efficacy. Moreover, tracking the moment-to-moment levels of self-confidence with the use of the mouse paradigm revealed self-confidence to also vary abruptly during time-outs in a volleyball contest (Gernigon et al., 2002).

Given the relevance of both competitive anxiety and self-confidence regarding performance and given the apparently dynamical behaviors of these variables, this first study aims to examine whether social perceptions of competitive anxiety and self-confidence are influenced by the history of performance—as reflected by ongoing scoring—and could thus be considered psychological features of momentum. This study also aims to examine whether ongoing scoring entails nonlinear variations in these variables and whether these potential history-dependent nonlinear variations might display hysteresis patterns. Sequences of a table tennis match were used to create the experimental conditions of the study because in this sport, performance yields numerically countable points that unfold quickly through discrete exchanges. Therefore, table tennis lends itself well to the manipulation
of scenarios of scoring with the use of video. Scoring was chosen as a potential trigger of PM because running score or performance is the most commonly used independent variable in experimental studies that successfully induce PM, whether these studies are based on controlled scenarios (e.g., Markman & Guenther, 2007; Vallerand et al., 1988), or on bogus performance feedback in motor or sport tasks (e.g., Kerick et al., 2000; Perreault et al., 1998; Shaw et al., 1992; Silva et al., 1992; Stanimirovic & Hanrahan, 2004). Because PM was being studied in the perspective of dynamical systems, scoring was considered to be the control parameter, and as such, was manipulated to gradually vary increasingly versus decreasingly (Haken et al., 1985). Taking a several-point lead or taking a several-point lag respectively increases or decreases probabilities of success (Martens et al., 1990); moving away from a desired goal entails negative emotions (e.g., Carver & Scheier, 1990; Hsee et al., 1994; Stanimirovic & Hanrahan, 2004). Consequently, cognitive anxiety should be lower and self-confidence should be higher in the increasing scenario than in the decreasing scenario of scoring. These differences should be due to changes of the variables in each scenario. Thus, considering each scenario separately, with a gradual evolution from negative to positive score gaps (i.e., increasing scenario), cognitive anxiety should decrease and self-confidence increase. On the other hand, with an evolution from positive to negative score gaps (i.e., decreasing scenario), cognitive anxiety should increase and self-confidence decrease. If the property of nonlinearity holds for PM as in dynamical systems, these variations in cognitive anxiety and self-confidence should occur abruptly following periods of stability. Furthermore, if PM can be considered a dynamical phenomenon, fluctuations in cognitive anxiety and self-confidence might display hysteresis patterns. In other words, changes in these variables should not occur at the same value of score gap (i.e., should lag) and would depend on whether they occur in an increasing or decreasing scenario of scoring. Moreover, differences of cognitive anxiety and self-confidence found between the two scenarios should be observed at certain score gap points (around the middle of table tennis games) and not at others (beginnings and ends of games). Because somatic anxiety is assumed to fade away once athletes start to perform (Martens et al., 1990), no hypotheses regarding the fluctuations of somatic anxiety were expressed.

Method

Participants. Twenty-nine Caucasian male regional-level table tennis players with average age of 23.3 (SD = 9.5) years voluntarily participated in this study. They were recruited from five clubs in the south of France whose presidents and coaches gave their consent.

Procedure. The protocol of the study was approved by the Ethical Review Board of the university of this article’s first author. Then the participants were enrolled in the study on the spot, during their training sessions, after having signed an informed consent form or provided a parental consent form for those who were minors. The experiment included two sessions, one month after the other whereby the athletes were presented randomly with an increasing scenario during one and a decreasing scenario in the other. For every session, each participant was taken to a specific dark room, adjacent to the training room, where the experimental device had been installed
beforehand. This device included a laptop and a video projector that were placed on a table at which the participant sat. The table was located 2 m in front of a light wall so that the projected images were 1.2 m wide × 1 m high. A pen and a pile of half-page sheets including items to be answered were also placed on the table. The participant was told that he would have to (a) watch the video of a game of a table tennis match; (b) empathize with the player who is visible from the back, in the foreground; (c) imagine he is playing the final of the most important competition of his career; and (d) imagine that both he and his opponent have already won two games in this final and are about to start the decisive game. Next, instructions about the procedure were provided and the participant began to carry out the task. This task consisted in (a) taking one sheet from the pile, indicating the current score, and answering the items before each new point of the game; (b) then pressing the space bar of the laptop to launch the video of the next exchange; (c) watching that complete exchange until two signs indicating the two players’ newly acquired scores appeared in full screen right after the end of the exchange; (d) pressing the space bar again to stop the video as soon as the two score signs appeared; (e) reporting the score that was displayed on the screen and answering the items on a new sheet, and so forth until the end of the game. To check whether the participant understood and followed the instructions correctly and to help him if necessary, the experimenter stayed in the room for the first 3 points, and then left.

Video scenarios had been edited based on sequences that had been recorded from an actual regional match that occurred in the Paris area, such that the players in the video were unknown to the participants of the study. The match had been simultaneously recorded by two cameras that were placed such that each one recorded a view from three-quarters behind one or the other of the two players. Thus, each point could be viewed either from the perspective of one or the other player. Afterward, specific points of the match were selected and edited to construct both increasing and decreasing scenarios. Consequently, both scenarios of scoring involved the same exchanges and were perfectly symmetrical regarding their contents. The only difference was that in the increasing scenario, the player who was visible from the back, in the foreground, was the future winner, whereas in the decreasing scenario the player in the foreground was the future loser. Both scenarios started at a score of 0–0 and ended at a score of 11–5 (or 5–11). After each point, two signs indicating the two players’ acquired scores appeared in full screen. Each sign was the same color (red or blue) as the shirt of its corresponding player and occupied the half screen corresponding to the side where that player was seen to perform. Both scenarios included a priming period intended to make the future winner (loser) begin by lagging behind (leading) by 5 points. Then, the period of interest for the study consisted of the future winner’s (loser’s) gradual recovery (loss of advantage) ending by his victory (defeat). As a result, score gaps unfolded as shown in Table 1.

### Table 1  Manipulation of Score Gaps According to Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Priming Period</th>
<th>Period Under Study</th>
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<tbody>
<tr>
<td><strong>Increasing Scenario:</strong></td>
<td>0</td>
<td>–1 –2 –3 –4 –5 –4 –3 –2 –1 0 +1 +2 +3 +4 +5 +6</td>
</tr>
<tr>
<td><strong>Decreasing Scenario:</strong></td>
<td>0</td>
<td>+1 +2 +3 +4 +5 +4 +3 +2 +1 0 –1 –2 –3 –4 –5 –6</td>
</tr>
</tbody>
</table>
**Measures.** Cognitive anxiety, somatic anxiety, and self-confidence were measured by three single items that were randomly presented. These items were selected from the Competitive State Anxiety Inventory 2 Revised (CSAI-2R; Cox, Martens, & Russel, 2003). Back-translation (Brislin, Lonner, & Thorndike, 1973) was used to ensure that the French items were reliable translations of the original ones. Thus, the items selected from Cox et al.’s questionnaire were first translated from English to French by a bilingual researcher. An independent bilingual translator then translated the French items back into English and confirmed that the back-translation was equivalent to the original items. The cognitive anxiety item was “I am concerned about losing,” the somatic anxiety item was “My body feels tense,” and the self-confidence item was “I feel self-confident.” Each item was answered on a 7-point Likert-type scale ranging from not at all (1) to very much so (7). Although some researchers advocated completing the CSAI-2 with directional scales that measure the interpretation of anxiety and self-confidence as either facilitative or debilitative (e.g., Jones, 1991; Jones & Swain, 1992), we have chosen not to use these additional scales for two reasons. One is theoretical since it is not clear what constructs the directional scales assess (e.g., Burton & Naylor, 1997; Lundqvist, Kenttä, & Raglin, in press). The other reason is methodological since adding three directional scales to the three intensity scales would not have been quite compatible with a dynamical measure that requires short durations of measurement to minimize participants’ loss of focus on the task.

**Analyses.** First, to test possible effects of the order of experiencing the two scenarios across the two sessions, multivariate and univariate $2 \times 2 \times 11$ analyses of variance (Scenario Order: Increasing-Decreasing vs. Decreasing-Increasing $\times$ Scenario: Increasing vs. Decreasing $\times$ Score Gap: ranging between –5 and +5) with repeated measures on the last two factors were processed on cognitive anxiety, somatic anxiety, and self-confidence. Once it was ascertained that there was no order effect, multivariate and univariate $2 \times 11$ analyses of variance (Scenario: Increasing vs. Decreasing $\times$ Score Gap: ranging between –5 and +5) with repeated measures on both factors and follow-up post hoc comparisons (trend analyses and Scheffé tests) were used, when necessary, to test our hypotheses regarding main effects for Scenario and Score Gap as well as Scenario $\times$ Score Gap interactions. Trend analyses were used to examine the different aspects of the shape of the function relating scoring and anxiety or self-confidence. First-order trends account for linear functions (fixed ratio), whereas second-order and third-order trends account for specific nonlinear functions (one and two changes in the ratio, respectively). In other words, a first-order trend indicates that the slope does not significantly change; a second-order trend corresponds to a quadratic function that displays one change in the slope, whereas a third-order trend corresponds to a cubic function that displays two changes in the slope. Moreover, Scheffé tests permitted the localization of the changes in the slopes. Significant differences in anxiety or self-confidence between adjacent or almost adjacent points of the game would reflect abrupt changes in these variables whereas significant differences appearing only between distant points would reflect slow changes. Nonlinearity could also be revealed by changes in anxiety or self-confidence that would be localized at specific moments during the game, whereas stability would be observed at other times, contrary to regular and continuous changes that would reflect linearity.
To support the existence of hysteresis effects, the nonlinear variations so defined should occur at different values of score gap, depending on the increasing or decreasing scenario of scoring. Hysteresis implies that for a given value of score gap there will be two different values for anxiety or self-confidence, except when the score gap is minimal or maximal. Therefore, in case of hysteresis, the effects of scenario should be significant only at specific score gaps occurring around the middle of the game and not at its beginning and its end.

**Results**

The multivariate and univariate $2 \times 2 \times 11$ analyses of variance (Scenario Order $\times$ Scenario $\times$ Score Gap) did not reveal significant main or interaction effect involving the order of the confrontations to the two scenarios ($p > .05$). Therefore, the present experimental design was considered valid and the hypotheses regarding the main or interaction effects of the scenarios and the score gaps could be tested. The means and the standard deviations for cognitive anxiety, somatic anxiety, and self-confidence according to the scenarios and to the score gaps are presented in Table 2.

The multivariate $2 \times 11$ analyses of variance (Scenario $\times$ Score Gap) revealed significant main effects of the scenario for cognitive anxiety ($\text{Wilks’s } \Lambda = .52, F(1, 28) = 25.91, p < .001$), somatic anxiety ($\text{Wilks’s } \Lambda = .76, F(1, 28) = 8.77, p < .01$), and self-confidence ($\text{Wilks’s } \Lambda = .35, F(1, 28) = 51.18, p < .001$). Significant effects of score gap were also found for cognitive anxiety ($\text{Wilks’s } \Lambda = .09, F(10, 19) = 19.50, p < .001$), somatic anxiety ($\text{Wilks’s } \Lambda = .10, F(10, 19) = 16.90, p < .001$), and self-confidence ($\text{Wilks’s } \Lambda = .08, F(10, 19) = 21.88, p < .001$). The Scenario $\times$ Score Gap interaction was significant for cognitive anxiety ($\text{Wilks’s } \Lambda = .39, F(10, 19) = 2.99, p < .05$) and somatic anxiety ($\text{Wilks’s } \Lambda = .29, F(10, 19) = 4.59, p < .01$, but not for self-confidence ($p > .05$).

Follow-up univariate analyses of variance revealed significant main effects of the scenario for cognitive anxiety ($F(1, 28) = 25.91, p < .001$, partial $\eta^2 = .48$), somatic anxiety ($F(1, 28) = 8.77, p < .01$, partial $\eta^2 = .24$), and self-confidence ($F(1, 28) = 51.18, p < .001$, partial $\eta^2 = .65$). The mean scores of cognitive and somatic anxieties were higher in the decreasing scenario, whereas the mean score of self-confidence was higher in the increasing scenario. The main effects of score gap were significant for cognitive anxiety ($F(10, 280) = 94.08, p < .001$, partial $\eta^2 = .77$), somatic anxiety ($F(10, 280) = 56.64, p < .001$, partial $\eta^2 = .67$), and self-confidence ($F(10, 280) = 136.02, p < .001$, partial $\eta^2 = .83$). The Scenario $\times$ Score Gap interaction was significant for cognitive anxiety ($F(10, 280) = 5.36, p < .001$, partial $\eta^2 = .16$) and somatic anxiety ($F(10, 280) = 7.63, p < .001$, partial $\eta^2 = .21$).

Regardless of the scenario, trend analyses revealed that cognitive anxiety significantly varied as a negative linear function of score gap ($p < .001$). No significant quadratic or cubic trends were found for cognitive anxiety ($p > .05$). Somatic anxiety significantly varied as both a negative linear function ($p < .001$) and a quadratic function ($p < .01$) of score gap. Scheffé tests showed that somatic anxiety was significantly higher at $SG_{-5}$ than at score gaps less negative than $SG_{-1}$; at $SG_{-4}$ and $SG_{-3}$ than at positive score gaps; at $SG_{-2}$, $SG_{-1}$, and $SG_{0}$ than at score gaps more positive than $SG_{+1}$; at $SG_{+1}$ than at score gaps more positive than $SG_{+2}$; and at $SG_{+2}$ than at $SG_{+5}$. Only a significant positive linear trend ($p < .001$) was found for self-confidence.
Table 2  Means and Standard Deviations ($M$ [$SD$]) for Cognitive Anxiety, Somatic Anxiety, and Self-Confidence According to Scenarios and Score Gaps

<table>
<thead>
<tr>
<th>Score Gaps</th>
<th>Cognitive Anxiety</th>
<th>Somatic Anxiety</th>
<th>Self-Confidence</th>
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<tbody>
<tr>
<td></td>
<td>Increasing</td>
<td>Decreasing</td>
<td>Increasing</td>
</tr>
<tr>
<td>All</td>
<td>3.30 (1.85)</td>
<td>4.13 (1.92)</td>
<td>3.71 (1.72)</td>
</tr>
<tr>
<td>SG_{-5}</td>
<td>5.31 (1.39)</td>
<td>5.90 (1.70)</td>
<td>5.45 (1.27)</td>
</tr>
<tr>
<td>SG_{-4}</td>
<td>4.69 (1.51)</td>
<td>5.59 (1.64)</td>
<td>4.72 (1.13)</td>
</tr>
<tr>
<td>SG_{-3}</td>
<td>4.21 (1.78)</td>
<td>5.48 (1.38)</td>
<td>4.34 (1.40)</td>
</tr>
<tr>
<td>SG_{-2}</td>
<td>3.66 (1.59)</td>
<td>5.21 (1.45)</td>
<td>4.17 (1.47)</td>
</tr>
<tr>
<td>SG_{-1}</td>
<td>3.34 (1.63)</td>
<td>4.79 (1.50)</td>
<td>3.86 (1.55)</td>
</tr>
<tr>
<td>SG_{0}</td>
<td>3.17 (1.69)</td>
<td>4.31 (1.47)</td>
<td>3.83 (1.47)</td>
</tr>
<tr>
<td>SG_{+1}</td>
<td>2.97 (1.61)</td>
<td>3.97 (1.50)</td>
<td>3.59 (1.64)</td>
</tr>
<tr>
<td>SG_{+2}</td>
<td>2.69 (1.56)</td>
<td>3.28 (1.10)</td>
<td>3.10 (1.74)</td>
</tr>
<tr>
<td>SG_{+3}</td>
<td>2.41 (1.62)</td>
<td>2.66 (1.11)</td>
<td>2.76 (1.55)</td>
</tr>
<tr>
<td>SG_{+4}</td>
<td>2.17 (1.42)</td>
<td>2.28 (1.31)</td>
<td>2.52 (1.50)</td>
</tr>
<tr>
<td>SG_{+5}</td>
<td>1.72 (1.22)</td>
<td>1.97 (1.12)</td>
<td>2.48 (1.55)</td>
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Considering each scenario separately (see Figure 1), in the increasing scenario, cognitive anxiety displayed both a significant negative linear trend ($p < .001$) and a significant cubic trend ($p < .05$), but no significant quadratic trend ($p > .05$). In this scenario, cognitive anxiety was significantly higher at $SG_{-3}$ and $SG_{-4}$ than at score gaps less negative than $SG_{-3}$ and $SG_{-2}$, respectively; at $SG_{-3}$ and $SG_{-2}$ than at score gaps more positive than $SG_{+1}$ and $SG_{+3}$, respectively; and at $SG_{+1}$ and $SG_{+0}$ than at $SG_{+3}$. In the decreasing scenario, the relationship between cognitive anxiety and score gaps displayed both a significant negative linear trend ($p < .001$) and a significant cubic trend ($p = .05$), but no significant quadratic trend ($p > .05$). In that scenario, cognitive anxiety was significantly lower at $SG_{+5}$ than at score gaps less positive than $SG_{+3}$; at $SG_{+4}$ and $SG_{+3}$ than at score gaps less positive than $SG_{+2}$; at $SG_{+2}$ and $SG_{+3}$ than at score gaps negative and more negative than $SG_{+2}$, respectively; and at $SG_{0}$ than at score gaps more negative than $SG_{-3}$. As regards somatic anxiety, only a significant negative linear trend ($p < .001$) was found in the increasing scenario. In the decreasing scenario, the relationship between somatic anxiety and score gaps displayed a negative linear trend ($p < .001$), a quadratic trend ($p < .001$), and a cubic trend ($p < .05$). In that scenario, somatic anxiety was significantly lower at $SG_{+5}$ than at score gaps less positive than $SG_{+3}$; at $SG_{+4}$ and $SG_{+3}$ than at score gaps less positive than $SG_{+2}$; and at $SG_{+2}$ than at score gaps ranging from $SG_{+1}$ to $SG_{+4}$.

Finally, comparing the two scenarios at identical score gaps revealed that cognitive anxiety was significantly higher in the decreasing scenario than in the increasing scenario at $SG_{-3}$, $SG_{-2}$, and $SG_{-1}$ only, whereas somatic anxiety was higher in the decreasing scenario than in the increasing scenario at $SG_{-1}$ only.

![Figure 1](image_url) — Fluctuations of the levels of cognitive anxiety (A) and somatic anxiety (B) according to scenarios and score gaps.
Discussion

One purpose of this first study was to examine whether competitive anxiety and self-confidence reflect psychological features of momentum. Both cognitive anxiety and somatic anxiety were found to be lower in the increasing scenario than in the decreasing scenario of scoring, whereas self-confidence was found to be higher in the increasing scenario. Therefore, these findings support previous research that have shown that moving toward (away from) a goal to be reached has positive (negative) consequences on affects (Hsee & Abelson, 1991; Hsee et al., 1994; Lawrence et al., 2002; Stanimirovic & Hanrahan, 2004) or on feelings of confidence (Shaw et al., 1992; Stanimirovic & Hanrahan, 2004).

To test whether the history dependences that were found can be likened to momentum phenomena, competitive anxiety and self-confidence variations were examined in relation to the ongoing scoring. The Scenario × Score Gap interaction was significant for cognitive and somatic anxieties only. Both forms of anxiety globally decreased in the increasing scenario whereas they both globally increased in the decreasing scenario. As regards cognitive anxiety, the significant differences did not occur between adjacent score gaps in the increasing scenario; the closest score gaps between which cognitive anxiety significantly changed downward were separated by an interval of two other score gaps (between $SG_{-5}$ and $SG_{-2}$, and between $SG_{-4}$ and $SG_{-1}$). Distal changes in cognitive anxiety were observed from the beginning to almost the end of the increasing scenario. In the decreasing scenario, the closest score gaps between which cognitive anxiety changed upward were separated by a shorter interval—of one score gap (between $SG_{+3}$ and $SG_{+1}$ only)—than for the increasing scenario. More distal changes in cognitive anxiety were observed almost throughout the decreasing scenario. Therefore, following Adler (1981) who considered PM to develop either suddenly or gradually, the constant decrease in cognitive anxiety as one progresses toward the winning can be seen as reflecting placid positive PM. However, PM associated with cognitive anxiety seems to be more explosive when negative, since the increase in cognitive anxiety undergoes acceleration after one has begun to lose a previous advantage.

As regards somatic anxiety, in the increasing scenario, the significant differences occurred between distant score gaps that were separated by intervals of at least three other score gaps. This slight decrease ended after score gap $SG_{-2}$, to then give way to an absence of significant differences (from $SG_{-1}$ to $SG_{+5}$). In the decreasing scenario, the closest score gaps between which somatic anxiety significantly changed upward were separated by a rather short interval of a single score gap (between $SG_{+3}$ and $SG_{+1}$). Larger intervals—of three score gaps—were observed from the beginning of the decreasing scenario to the score gap of $SG_{+2}$ after which no significant changes in somatic anxiety were found (from $SG_{+1}$ to $SG_{-5}$). Therefore, because of its slight and sometimes absent decrease during the progression toward winning, somatic anxiety can be seen as moderately paralleling placid positive PM. The weakness of the relatedness of somatic anxiety to positive PM might be due to the limited capacity of a hypothetical scenario to successfully activate a so bodily rooted variable. Although it is difficult to set up, an experiment based on actually experienced situations would most likely entail affective reactions (Lawrence et al., 2002) or elicit high levels of arousal that are prone to PM (Perreault et al., 1998). As for cognitive anxiety, somatic anxiety underwent a
more abrupt increase as participants lost their advantage. Moreover, the fact that this rapid increase then slowed down and reached a plateau supports the hypothesis of nonlinearity of negative PM with regard to somatic anxiety.

The present study also aimed to examine whether the combination of history dependence and nonlinearity of competitive anxiety and self-confidence could take the form of hysteresis patterns. Such was not the case since cognitive and somatic anxieties did not display abrupt changes in the increasing scenario, and since self-confidence did not vary differently according to the scenarios.

To conclude, regarding the main focus of this study it was shown that the most dynamical properties emerged as people progressively shifted from a situation of high probability of winning (beginning of the decreasing scenario) to a situation of high probability of loss (end of the decreasing scenario). It should be noted that the first situation corresponds to a move toward the outcome to be reached (winning), whereas the latter situation corresponds to a move toward the outcome to be avoided (losing). The literature is well documented on how approach and avoidance goals are related to anxiety and expectancies of success (e.g., Conroy et al., 2003; Elliot & Church, 1997; Elliot & McGregor, 2001) or affects (e.g., Carver, 2006), including within a dynamical systems perspective (Carver & Scheier, 1998, 2002). Consequently, the next study aims to examine how approach and avoidance goals relate to PM and whether they display the dynamical properties of history dependence and nonlinearity.

Study 2

The rate that characterizes how one is moving regarding a specific goal relates to different ranges of emotions and feelings, depending on whether one is attempting to reach a desired outcome or to avoid an undesired outcome. According to Carver and Scheier (Carver, 2006; Carver & Scheier, 1998), doing well or poorly at approaching a desired outcome entails affects ranging from elation to sadness and depression, whereas doing well or poorly at avoiding an undesired outcome yields affective consequences ranging from relief and serenity to fear and anxiety. In contemporary models of achievement motivation (e.g., Elliot, 2005; Elliot & McGregor, 2001), individuals are seen to strive toward feeling successful and to avoid feeling unsuccessful, whereby success is defined by either self- or other-referenced criteria. Combining appetitive versus aversive valence of an outcome with self- versus other-referenced definition of success led authors to consider a $2 \times 2$ achievement goal framework including mastery-approach (MAp), performance-approach (PAp), mastery-avoidance (MAv), and performance-avoidance (PAv) goals (e.g., Elliot & McGregor, 2001). MAp goals involve focusing on performing a task well or improving in that task. PAp goals correspond to aiming at outperforming others. MAv goals consist in focusing on not making mistakes or not doing worse than a previous performance. PAv goals involve focusing on not being outperformed by others. These goals were found to relate differently to feelings and emotions that are close to those of our first study, as well as to contextual conditions such as those we experimentally induced. MAp goals positively relate to competence expectancies (Elliot & Church, 1997) and perceived situational importance in terms of competence valuation (Elliot & McGregor, 2001). PAp goals are positively
related to competence expectancies (Elliot & Church, 1997), competence valuation (Elliot & McGregor, 2001), and fear of failure (e.g., Conroy et al., 2003; Elliot & McGregor, 2001). MAv goals are positively linked to competence valuation (Elliot & McGregor, 2001) and fear of failure (e.g., Conroy et al., 2003; Elliot & McGregor, 2001). PAv goals positively relate to competence valuation (Elliot & McGregor, 2001) and fear of failure (e.g., Conroy et al., 2003; Elliot & McGregor, 2001), but negatively relate to competence expectancies (Elliot & Church, 1997).

Research conducted in natural sport contexts has shown that states of goal involvement emerge and fluctuate nonlinearly—sometimes with extremely abrupt changes—according to the ecological constraints the course of events is punctuated with (Gernigon, d’Arripe-Longueville, Delignières, & Ninot, 2004). However, these features cannot be considered as properties of dynamical systems since no control parameters can be manipulated in a natural context. Consequently, the purpose of this second study is to examine whether social perceptions of MAp, PAp, MAv, and PAv goals are influenced by the history of performance and thus reflect psychological features of momentum. This study also aims at examining whether the history of scoring entails nonlinear variations in these variables and whether these potential history-dependent nonlinear variations might display hysteresis patterns. This study is based on the same scenarios of table tennis as in Study 1.

Hypotheses were based on both the findings of Study 1 relating to the dynamics of anxiety and self-confidence, and the links that exist between these variables or related constructs and achievement goals. Given the existing positive links between MAp goals and competence expectancies, MAp was expected to behave like self-confidence and therefore to be higher in the increasing scenario than in the decreasing scenario. PAp goals, which have positive links with both competence expectancies and fear of failure, could either parallel the dynamical pattern of self-confidence or that of anxiety. However, because Study 1 revealed opposite patterns for self-confidence and anxiety, no predictions were made regarding PAp goals. Given the positive relationships that exist between both MAv and PAv goals and fear of failure, MAv and PAv goals were expected to behave in the same way as anxiety and therefore to be higher in the decreasing scenario than in the increasing scenario. For the same reasons, the increasing scenario was expected to bring about a decrease in MAv and PAv goals and an increase in MAp goals. On the other hand, the decreasing scenario was expected to bring about the inverted pattern of results. If achievement goals possess the property of nonlinearity that belongs to dynamical systems, their variations should occur abruptly following periods of stability. Furthermore, their fluctuations might display hysteresis patterns.

**Method**

**Participants and Procedure.** Twenty-three male table tennis players whose average age was 24.3 (SD = 7.3) years voluntarily participated in this second study. None of them had participated in Study 1. Their characteristics, the conditions of their recruitment, the ethical guarantees, and the procedure of the experiment were the same as those in Study 1.

**Measures.** MAp, PAp, MAv, and PAv goals were measured by four single items that were randomly presented. These items were selected from the 2 × 2 Goal Involvement States Questionnaire for Sport (GISQ-S; Ferron, Le Bars, & Gernigon,
2005), which was itself a state-like form French adaptation of the $2 \times 2$ Achievement Goals Questionnaire for Sport (AGQ-S; Conroy et al., 2003). The MAp item was “I try to apply myself technically and tactically,” the PAp item was “I want to show the other player I am the best,” the MAv item was “I am concerned that I may not perform as well as I possibly can,” and the PAv item was “I want to avoid being the worst of the two players.” Each item was answered on a 7-point Likert-type scale ranging from not at all (1) to very much so (7).

Results

The multivariate and univariate $2 \times 2 \times 11$ analyses of variance (Scenario Order $\times$ Scenario $\times$ Score Gap) did not reveal significant main or interaction effect involving the order of the confrontations to the two scenarios ($p > .05$), thus validating the experimental design and allowing the tests of the hypotheses. The means and the standard deviations for MAp, PAp, MAv, and PAv goals according to the scenarios and to the score gaps are presented in Table 3.

The multivariate $2 \times 11$ analyses of variance (Scenario $\times$ Score Gap) revealed significant main effects of the scenario only for PAp goals (Wilks’s $\Lambda = .58, F(1, 22) = 15.81, p < .001$) and MAv goals (Wilks’s $\Lambda = .67, F(1, 22) = 10.81, p < .01$). A significant effect of score gap was found only for MAv goals (Wilks’s $\Lambda = .08, F(10, 13) = 15.49, p < .001$). The Scenario $\times$ Score Gap interaction was significant only for MAv goals (Wilks’s $\Lambda = .16, F(10, 13) = 6.89, p < .001$) and PAv goals (Wilks’s $\Lambda = .31, F(10, 13) = 2.86, p < .05$).

Follow-up univariate analyses of variance revealed significant main effects of the scenario for PAp goals ($F(1, 22) = 15.81, p < .001$, partial $\eta^2 = .42$) and MAv goals ($F(1, 22) = 10.81, p < .01$, partial $\eta^2 = .33$). The mean score of PAp goals was higher in the increasing scenario, whereas the mean score of MAv goals was higher in the decreasing scenario. The main effect of score gap was significant for MAv goals ($F(10, 220) = 45.13, p < .001$, partial $\eta^2 = .67$). The Scenario $\times$ Score Gap interaction was significant for MAv goals ($F(10, 220) = 8.84, p < .001$, partial $\eta^2 = .29$) and PAv goals ($F(10, 220) = 8.54, p < .001$, partial $\eta^2 = .28$).

Regardless of the scenario, trend analyses revealed that MAv scores significantly varied as a negative linear function of score gap ($p < .001$). Neither quadratic nor cubic trends were significant. Considering each scenario separately, in the increasing scenario, MAv scores (see Figure 2) displayed significant negative linear ($p < .001$), quadratic ($p < .01$), and cubic ($p < .01$) trends. MAv scores were significantly higher at $SG_{-5}$ and $SG_{-4}$ than at score gaps less negative or more positive than $SG_{-3}$ and $SG_{0}$, respectively. MAv scores were also higher at $SG_{-3}$ than at $SG_{-5}$. In the decreasing scenario, the relationship between MAv scores and score gaps displayed significant negative linear ($p < .001$), quadratic ($p < .01$), and cubic ($p < .01$) trends. MAv scores were significantly lower at $SG_{+5}$, $SG_{+3}$, and $SG_{+2}$ than at score gaps less positive or more negative than $SG_{+1}$, and $SG_{+2}$ than at score gaps more positive than $SG_{+1}$. As regards PAv scores, only a significant negative trend was found in the increasing scenario ($p < .01$). In the decreasing scenario, the relationship between PAv scores and score gaps displayed both a positive linear trend ($p = .05$) and a quadratic trend ($p < .01$). In spite of these significant trends, no significant differences were revealed by Scheffé tests for PAv scores within each scenario.
Table 3: Means and Standard Deviations ($M \ [SD]$) for Achievement Goals According to Scenarios and Score Gaps

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<tr>
<td>All</td>
<td>6.11 (1.26)</td>
<td>5.96 (1.21)</td>
<td>5.78 (1.42)</td>
<td>4.80 (1.69)</td>
<td>3.12 (1.90)</td>
<td>4.12 (1.97)</td>
<td>3.49 (2.20)</td>
<td>3.73 (1.99)</td>
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<tr>
<td>SG$_{+5}$</td>
<td>5.91 (1.31)</td>
<td>5.17 (1.56)</td>
<td>4.52 (1.50)</td>
<td>5.39 (1.62)</td>
<td>5.48 (1.31)</td>
<td>5.17 (1.75)</td>
<td>4.39 (2.02)</td>
<td>2.91 (2.00)</td>
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<tr>
<td>SG$_{+4}$</td>
<td>5.96 (1.30)</td>
<td>5.65 (1.30)</td>
<td>4.83 (1.37)</td>
<td>5.00 (1.95)</td>
<td>4.22 (1.76)</td>
<td>5.26 (1.86)</td>
<td>4.39 (1.92)</td>
<td>2.83 (1.77)</td>
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<tr>
<td>SG$_{+3}$</td>
<td>6.22 (1.13)</td>
<td>5.96 (1.15)</td>
<td>5.13 (1.25)</td>
<td>4.83 (1.77)</td>
<td>3.74 (1.66)</td>
<td>5.39 (1.78)</td>
<td>3.96 (2.08)</td>
<td>3.22 (1.91)</td>
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<tr>
<td>SG$_{+2}$</td>
<td>6.26 (1.10)</td>
<td>6.13 (0.92)</td>
<td>5.83 (1.23)</td>
<td>4.91 (1.65)</td>
<td>3.26 (1.63)</td>
<td>5.13 (1.63)</td>
<td>3.48 (2.13)</td>
<td>3.70 (1.84)</td>
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<tr>
<td>SG$_{+1}$</td>
<td>6.22 (1.17)</td>
<td>6.35 (0.83)</td>
<td>5.91 (1.35)</td>
<td>4.96 (1.58)</td>
<td>3.13 (1.71)</td>
<td>4.83 (1.67)</td>
<td>3.52 (2.09)</td>
<td>4.13 (2.07)</td>
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<tr>
<td>SG$_{0}$</td>
<td>6.09 (1.08)</td>
<td>6.30 (0.76)</td>
<td>6.39 (0.84)</td>
<td>5.00 (1.71)</td>
<td>2.83 (1.83)</td>
<td>4.52 (1.70)</td>
<td>3.35 (2.40)</td>
<td>4.26 (2.03)</td>
</tr>
<tr>
<td>SG$_{-1}$</td>
<td>6.26 (1.10)</td>
<td>6.30 (0.88)</td>
<td>6.30 (1.15)</td>
<td>5.17 (1.53)</td>
<td>2.57 (1.75)</td>
<td>4.22 (1.62)</td>
<td>3.22 (2.21)</td>
<td>4.22 (1.95)</td>
</tr>
<tr>
<td>SG$_{-2}$</td>
<td>6.43 (0.79)</td>
<td>6.39 (0.89)</td>
<td>6.35 (1.19)</td>
<td>4.96 (1.46)</td>
<td>2.43 (1.50)</td>
<td>3.48 (1.68)</td>
<td>3.17 (2.23)</td>
<td>4.09 (1.95)</td>
</tr>
<tr>
<td>SG$_{-3}$</td>
<td>6.04 (1.61)</td>
<td>6.00 (1.24)</td>
<td>6.00 (1.33)</td>
<td>4.65 (1.47)</td>
<td>2.48 (1.93)</td>
<td>3.00 (1.41)</td>
<td>3.22 (2.32)</td>
<td>4.22 (2.07)</td>
</tr>
<tr>
<td>SG$_{-4}$</td>
<td>6.22 (1.09)</td>
<td>5.78 (1.31)</td>
<td>6.04 (1.46)</td>
<td>4.09 (1.65)</td>
<td>2.39 (1.78)</td>
<td>2.13 (1.25)</td>
<td>2.83 (2.21)</td>
<td>3.96 (1.94)</td>
</tr>
<tr>
<td>SG$_{-5}$</td>
<td>5.57 (1.93)</td>
<td>5.48 (1.68)</td>
<td>6.00 (1.54)</td>
<td>3.83 (1.87)</td>
<td>1.83 (1.23)</td>
<td>2.22 (1.35)</td>
<td>2.83 (2.33)</td>
<td>3.48 (2.02)</td>
</tr>
</tbody>
</table>
Finally, comparing the two scenarios at identical score gaps revealed that MAv scores were significantly higher in the decreasing scenario than in the increasing scenario only at score gaps comprised from $SG_{-3}$ to $SG_{+1}$. No significant differences were found for PAv scores between the two scenarios at identical score gaps.

**Discussion**

This second study aimed to examine whether states of goal involvement reflect psychological features of momentum. Only PAp and MAv goals were influenced by the scenario of scoring. PAp goals were higher in the increasing scenario than in the decreasing scenario, whereas, as expected, MAv goals were higher in the decreasing scenario. However, only MAv goal involvement fluctuated differently depending on the scenario, since the Scenario × Score Gap interaction was not significant for PAp and MAp goals, and since the post hoc comparison did not reveal significant differences within each scenario for PAv goals. Significant differences for MAv goals were only found at the beginning of each scenario. In the increasing scenario, the closest score gaps between which MAv scores significantly changed downward were separated by an interval of one score gap (between $SG_{-5}$ and $SG_{-3}$) and no significant differences were found from score gap $SG_{-2}$ to score gap $SG_{+5}$. In the decreasing scenario, the closest score gaps between which MAv scores changed upward were separated by an interval of two score gaps (between $SG_{+4}$ and $SG_{+1}$) and no significant differences were found from score gap $SG_{+1}$ to score gap $SG_{+5}$. As a result, the sensitivity of MAv goals to each scenario took the shape of rapid variations that were followed by a long phase of stability. Therefore, positive and negative PM associated to MAv goals in the increasing scenario and the decreasing scenario, respectively, can be described as explosive (Adler, 1981).

Another purpose of the current study was to seek hysteresis patterns in the ebb and flow of goal involvement. Only MAv goals showed the nonlinear variations that characterize such patterns. Fast variations of MAv scores occurred at values of score

**Figure 2** — Fluctuations of the levels of involvement toward mastery-avoidance goals according to scenarios and score gaps.
gaps that differed depending on the scenario: From $SG_{-3}$ to $SG_{-3}$ for the increasing scenario; from $SG_{+3}$ to $SG_{+2}$ for the decreasing scenario. Moreover, significant differences between the two scenarios were observed for MAv scores around the middle of the game whereas no differences were found at both the beginning and the end of the game. As a result, these findings support the existence of a particular noteworthy hysteresis effect for MAv goals. Most often, hysteresis reflects the resistance of a dynamical system to recover its initial state while the control parameter moves back to restore this state. This resistance results in a delayed recovery that is shown by a lengthening phase of stability that precedes an abrupt change. On the contrary, the present findings indicate early changes followed by phases of stability, thus suggesting anticipation rather than delay. Such a pattern is rare and corresponds to what physicians call negative hysteresis (e.g., Choi et al., 1999), or inverted hysteresis (e.g., Valvidares, Álvarez-Prado, Martín, & Alameda, 2001).2

From a psychological standpoint, it is not certain that this anticipation stems from the scripts (e.g., Abelson, 1981) that individuals have routinely developed across familiar situations. According to Atance and O’Neill (2005), scripts are event-based knowledge allowing individuals to think about the future, but they do not necessarily imply a projection of oneself into the future. These authors (Atance & O’Neill, 2001, 2005) have developed the concept of episodic future thinking, which refers to projecting oneself into the future to preexperience an event. Episodic future thinking is considered to be implicated in goal attainment (Atance & O’Neill, 2001), to allow a person to hypothesize and anticipate novel events, and to take into account impediments that may affect his or her self in the future (Atance & O’Neill, 2005). In the present case, this projection—into a possible future of win or lose—might have been activated by the first occurring indices that were contrary to the previously established situation: These indices would have been either the first points the player won while he was losing in the beginning of the increasing scenario, or the first points he lost while he was leading in the beginning of the decreasing scenario. Regarding goal involvement, PM could therefore be defined from a dynamical perspective as an anticipated escape from the system toward a likely future level of MAv that is different from the current one, whether scoring is increasing or decreasing.

Given the dynamical properties that were displayed by MAv goals, the question of why these goals are so sensitive to the history of performance is of interest. Comparing MAv goals and both forms of anxiety that were examined in the first study reveals quite similar patterns of evolution of these variables in the decreasing scenario. This similarity can be explained mainly by the specific affective content of the MAv item. In addition, it might be that starting to move toward a possible loss increases the fear of failure—a feeling close to anxiety—which is known to be related to avoidance goals (Conroy & Elliot, 2004; Conroy et al., 2003; Elliot & McGregor, 2001). The fact that only MAv goals were influenced by the scenarios might be explained by the relationship that exists between anxiety and motor performance. In perceptual-motor tasks, anxiety has been found to increase reaction time (Murray & Janelle, 2003) and to impair the efficiency of information processing at the perceptual level (e.g., Janelle, Singer, & Williams, 1999) and performance effectiveness in table tennis tasks (Williams, Vickers, & Rodrigues, 2002). Faced with such deleterious effects, it would not be surprising for a player to be focused on not having his motor behavior impaired. Therefore, MAv goals—which involve
focusing on not making mistakes or not doing worse than previously—might well be the main concern of athletes in critical situations of doubt. On the contrary, this concern might vanish with anxiety as soon as things get better, as in the beginning of the increasing scenario.

In conclusion of this second study, MAv goals clearly appear to be the most history-dependent goals. This dependence confirms the importance of considering MAv goals as a motivational construct involved in achievement settings (Elliot & McGregor, 2001). A mixed profile of determinants is usually assigned to MAv goals because they combine optimal (mastery) and non optimal (avoidance) components (e.g., Elliot & McGregor, 2001). However, the present findings reinforce Elliot’s (2005) contention that MAv goals are prevalent when a self-referenced definition of competence is activated in an achievement situation that elicits a potentially threatening temporal comparison. According to this author, this prevalence might apply to anyone facing the perspective of losing his or her abilities, such as persons who are aging, athletes as they approach the end of their career, individuals who feel they have peaked at work, and the like.

General Discussion

Borrowing the dynamical systems approach (e.g., Nowak & Vallacher, 1998), the present research provided preliminary evidence for the existence of nonlinear and history effects in PM. A first study revealed that variations in cognitive and somatic anxieties reflected placid positive momentum as participants empathized with a sport situation that was gradually progressing from a likely defeat toward winning (increasing scenario), whereas these variables displayed explosive negative momentum in the inverted scenario (decreasing scenario). The fact that negative PM might be triggered more easily and more abruptly than positive PM is consistent with the asymmetry between economic losses and gains that is described in Kahneman and Tversky’s (1979) prospect theory. According to these authors, it is more painful to give up an asset than it is pleasurable to obtain it. Hence, the value function is steeper for losses than for gains. More generally, this asymmetrical pattern is consistent with the pervasive fact that negatively valenced events have a greater psychological impact than equivalent positively valenced events (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001).

A second study, which addressed goal involvement states, revealed that MAv goals were highly sensitive to scenarios of ongoing performance, undergoing a nonlinear decrease in the increasing scenario and a nonlinear increase in the decreasing scenario. The ebb and flow of MAv goals even displayed negative hysteresis, a typically dynamical pattern. This negative hysteresis pattern indicates that the history embedment of PM implies the future in terms of anticipation of desirable or undesirable outcome. Further research from the perspective of dynamical systems might well allow explosive PM to be characterized as a positive or negative hysteresis phenomenon because the concept of hysteresis accounts for either the past (positive hysteresis) or the foreseen future (negative hysteresis) of an ongoing history.

Besides the inclusion of achievement goals as a feature of PM, the present research is innovative in that it is the first that accounts for the dynamics of PM per se. Moreover, this research offers new perspectives regarding Carver and Scheier’s
control process theory of affects. According to these authors, abrupt changes in affect stem from sensed changes in the rate of movement toward a desired outcome or away from one that is to be avoided (Carver, 2006; Carver & Scheier, 1998; see also Hsee et al., 1994, for desired outcomes only). We agree that changes in rate (i.e., acceleration or deceleration) may offer sufficient conditions for abrupt affective reactions. However, both forms of anxiety abruptly changed while the scenario of scoring regularly decreased, a behavior that is specific to dynamical systems. Consequently, we would argue that changes in rate are not a necessary condition for abrupt affective reactions. Moreover, it is unlikely that only one or a few key determinants of abrupt changes in affects exist. Rather, according to dynamical system theory, the nonlinear changes that are observed in an order parameter—while the control parameter gradually varies—emerge from the complex interactions of the numerous elements of that system and from its own history (e.g., Haken et al., 1985). Given the properties that were found for anxiety, such a process might apply to affective states. This dynamical perspective is not contradictory to Carver and Scheier’s theory. Indeed, changes in the rate of moving toward or away from an outcome may be considered to be merely one type of precipitating events that might bring about abrupt affective reactions in the context of a meaningful ongoing history.

It should be pointed out that this research presents certain limitations. First, the affective dimension that was included in the MAv item confounds the respective properties of being concerned and of avoiding not performing as well as possible. From an applied perspective, this confusion is not very problematic since the literature consistently shows that MAv goals are closely related to negative affects such as fear of failure or worry (e.g., Conroy & Elliot, 2004; Conroy et al., 2003; Elliot & McGregor, 2001). However, from a theoretical viewpoint, caution should be exercised when interpreting the findings pertaining to MAv goals in the absence of an achievement goals questionnaire in sport that could specifically tap goals without their affective correlates. Second, the fact that the experiments were based on virtual situations may have lessened the impact of the scenarios on the participants’ perception of momentum. For instance, this might explain why no effects were found for MAp and PAv goals. Perreault et al. (1998) have assumed that PM is most likely experienced in tasks requiring a great deal of effort. Third, specifically regarding the lack of effects for MAp goals, we might also incriminate the phrasing of the MAp item whose words “technically and tactically” involve a task-based standard. According to achievement goal theorists (e.g., Elliot & McGregor, 2001; Elliot & Murayama, 2008), MAp goals involve competence as defined either in task-based or intrapersonal terms. Hence, the present research did not test whether intrapersonal MAp goals such as trying to take one’s performance a level higher could be more sensitive to the scenarios. Fourth, the fact that the increasing and the decreasing scenarios included the same but reversed series of exchanges could have made the participants in every second session anticipate what could come next—on the basis of their experience in the first session—and thus bias their answers to items. However, whether participants did recognize the situations or not, the absence of order effects in both Studies 1 and 2 clearly shows that their answers to items in a given scenario did not depend on whether they viewed the other scenario one month earlier or not. Fifth, manipulating the evolution of score gaps entailed the manipulation of the distance between any given score configuration and the outcome to be reached (i.e., winning) or avoided (i.e.,
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The significant main effects for score gap that were found in the present studies do reflect the effects of distance regardless of the scenario that led to specific score gaps. However, the confusion between the variables “distance from the outcome” and “movement toward (away from) the outcome” is almost inevitable in any experimental design intended to specifically examine the effect of movement (see Hsee et al., 1994; Lawrence et al., 2002).

The new perspective of PM that is sketched here completes the current models (e.g., Markman & Guenther, 2007; Taylor & Demick, 1994; Vallerand et al., 1988) by characterizing the dynamics of PM and specifying the role of ongoing history in triggering the phenomenon. Considering the different kinds of variables that are assumed to be associated with PM (e.g., Taylor & Demick, 1994; Vallerand et al., 1988), we might define PM as a positive or negative dynamics of cognitive, affective, motivational, physiological, and behavioral responses (and their couplings) to the perception of movement toward or away from either an appetitive or aversive outcome. Such a perception might emerge from both the feedback and feedforward that are provided by the specific ongoing history of events. Of course, future research is needed to support this definition and to get a more complete view of the dynamics of PM. For example, a number of psychological, physiological, and behavioral variables that might feature in PM have not yet been examined in the dynamical perspective. Further examining the dynamics of PM will require an interdisciplinary approach to also identify the couplings that may exist among these different kinds of variables. Because the variables under study in the present research displayed different levels of dynamics, future research should determine the reasons for such differences. As mentioned above, it might be possible that the seemingly less dynamical variables behave more dynamically in real situations, where participants actually have to exert a great deal of effort (Perreault et al., 1998). Because only negative hysteresis was found, we need to know whether specific types of PM may be characterized by positive hysteresis patterns, as Markman and Guenther’s (2007) finding of inertia regarding PM has led us to expect. If so, research should also determine what circumstances might elicit positive or negative pattern of hysteresis. From a practical standpoint, improving the knowledge of both the features and the dynamics of PM in achievement settings might lead to the identification of strategies of mental control and goal focus that might be used to stabilize states of positive PM and to delay or even cancel the occurrence of negative PM. To conclude, the present findings incite researchers to pursue the examination of the dynamics of PM—and more generally that of cognitions, affects, and behaviors in achievement settings—from the perspective of dynamical systems.

Notes

1. Consistent with classical measures of achievement goals (e.g., Conroy et al., 2003; Elliot & McGregor, 2001), the MAv item contained specific affective content implied by the word concerned. Recently, Elliot and Murayama (2008) published a revised Achievement Goals Questionnaire for academics that is devoid of affective connotation. However, at the time when the current study was conducted, this instrument was not yet published and, to date, no similarly revised achievement goals questionnaire exists for sport settings. Although we ardently wish that a new era of research in sport based on an ideal measure of achievement goals will soon arrive, we agree with Elliot and Murayama’s (2008) contention that the spuriousness of the empirical
corpus yielded by the traditional measures of goals is unlikely. Specifically regarding MAv goals, the literature consistently showed that these goals and negative affects, such as fear of failure and worry, are bound together (e.g., Conroy & Elliot, 2004; Elliot & McGregor, 2001).

2. Tuller, Case, Ding, and Kelso (1994) used the term enhanced contrast to refer to a similar pattern they found in an investigation of the nonlinear relationships between acoustic perception and the dichotomous categorization of speech. However, we prefer the term negative hysteresis because it better parallels its counterpart, hysteresis, and thus can be generalized to any domain of application of the phenomenon.

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