Interactions Between Performance Pressure, Performance Streaks, and Attentional Focus

Rob Gray and Jonathan Allsop
University of Birmingham

How is performance under pressure influenced by the history of events that precede it, and how does the pressure outcome influence the series of events that follow? A baseball batting simulation was used with college players to investigate these questions. In Experiment 1, the difficulty of the simulation was first adaptively adjusted to equate performance level. Batters next completed 20 at-bats used to classify them into one of three performance groups (normal, cold streak, or hot streak) followed by a one at-bat pressure condition. Finally, performance was evaluated over a period of 20 postpressure at-bats. In Experiment 2, a series of secondary tasks were added to assess attentional focus. In both experiments, whether batters succeeded or failed under pressure was significantly related to their performance history immediately before the pressure event, with the normal group having the poorest pressure performance. Performance postpressure was significantly related to both the pressure outcome and prepressure performance. These performance effects were related to changes in the batter’s attentional focus as shown by changes in secondary task accuracy.

Keywords: motor control, physical performance, sport, sport psychology

Over the past 30 years, the question of why some athletes fail under pressure whereas others thrive has remained a popular research topic in sports science. As reviewed in Beilock and Gray (2007), the phenomenon of “choking under pressure” has been studied from multiple different angles, investigating mechanisms including attentional control, biomechanics, kinematics, anxiety, effort, and social threat. An issue that has not been investigate in this previous research is the relationship between pressure and streaks in performance. For example, how is performance under pressure influenced by the history of events that precede it? Would a performer on a cold streak (i.e., a performance slump) perform better or worse under pressure than a performer on a hot streak? A related question concerns how the pressure outcome influences the series of events that happens after the pressure is removed. Does failing under pressure induce cold streaks? Are performers who succeed under pressure more likely to go on a hot streak?

There are multiple mechanisms through which performance streaks might be related to performance under pressure. First, it has been shown that confidence level can be related to performance streakiness, with the number of consecutive successes being positively related to confidence (Ayton & Fischer, 2004). Similarly, it has been shown that self-efficacy can be related to one’s performance history (Avugos, Bar-Eli, Ritov, & Sher, 2013; Moritz, Feltz, Fahrbach, & Mack, 2000). Since previous research has shown that confidence or expectancy of success is a strong predictor of performance under pressure (e.g., Baumeister, Hamilton, & Tice, 1985; Hardy, Woodman, & Carrington, 2004), it might be expected that changes in confidence level brought on by performance streaks might also influence subsequent success under pressure.

Another mechanism that might link performance streaks and success under pressure is changes to the attentional focus adopted by the performer. This is the primary interest of the current study. Gray (2004) investigated the relationship between performance streaks and attentional focus in baseball batting using a dual-task methodology. In this study, batters were asked to perform one of two secondary tasks while batting: a skill-focused task that involved judging whether their bat was moving up or down at the instant a tone was presented or an extraneous task that involved judging the frequency of the tone. A key element of this experiment was that the batter was told which secondary task to perform after their swing was completed, and trials were also interleaved in which no secondary response was required. Therefore, it was argued that the secondary tasks would not induce shifts in attentional focus during batting.

Using this methodology, it was found that batters with a high number of hits in the previous experimental block (i.e., on a hot streak) had significantly lower accuracy on the skill-focused secondary task as compared...
with batters with a low number of hits (i.e., cold streak). Gray (2004) proposed that this effect most likely occurred because the extended period of poor performance for cold streak batters induced an inward shift of attention in attempt to correct performance errors; that is, batters on a cold streak began focusing on their bat movement to assess why they were not making solid contact with the ball. Conversely, batters on a hot streak would have no such incentive to focus on skill execution so their attention was directed elsewhere. Consistent with this proposal, Gray, Beilock, and Carr (2007) reported that batters on a hot streak are better able to judge the outcome of their action (where the ball lands on the field after it is hit) relative to when they are on a cold streak. Together, these findings suggest that more attention is allocated to the mechanics of skill execution during a cold streak and more attention is available to be allocated to the external environment during a hot streak.

How might an increase in skill-focused attention resulting from a cold streak be related to performance under pressure? The explicit monitoring theory of choking proposes that pressure serves to turn attention inward and disrupt automaticity (Baumeister, 1984). Consistent with this proposal, Gray (2004) also found that batters were more accurate in the skill-focused secondary task described above (indicative of an inward attentional focus on skill execution) in a pressure condition as compared with both prepressure and a nonpressure control group. Therefore, if we assume that an athlete on a cold streak is focusing their attention on skill execution whereas an athlete on a hot streak is not, then the former athlete should be relatively unaffected by pressure and the latter will be more likely to suffer from explicit monitoring and fail under pressure. The proposal that different foci of attention (brought on by performance streaks) can lead to different outcomes under pressure is supported by previous research that has shown that the incidence of “choking under pressure” can be significantly reduced by the introduction of secondary tasks deliberately designed to shift the performer’s attention (e.g., Jackson, Ashford, & Norsworthy, 2006; Land & Tenenbaum, 2012; Lewis & Linder, 1997; Mullen & Hardy, 2010).

A separate issue concerns what happens after the pressure is gone and an athlete continues to perform in nonpressure situations. Does an athlete’s postpressure performance suffer when they fail under pressure, or are failures quickly forgotten? There are some famous examples of a single instance of choking under pressure marking the abrupt end of a previously successful career. For example, kicker Scott Norwood of the Buffalo Bills retired the year after missing the potential game-winning field goal in Super Bowl XXV. We have recently shown that when a secondary task is used to induce focus on skill execution (i.e., the attentional focus thought to be associated with failing under pressure) this attentional focus can spill over into subsequent performance under normal, single-task conditions (Beilock & Gray, 2012). Therefore, one might expect athletes who fail under pressure to be more likely to have a cold streak after the pressure is removed as compared with performers that succeed.

The goal of the current study was to investigate the possible relationships among prepressure performance, pressure outcome, and postpressure performance from an attentional control perspective. In any study of performance streaks, it is important to clearly define the terms and concepts used. In the current study, hot streak is used to refer to an extended period (i.e., large number of samples) during which a player’s batting average was significantly higher than their typical level of performance, while cold streak is used to refer to an extended period during which their batting average is significantly lower than normal (Siwoff, Hirdt, & Hirdt, 1988). These terms are defined more specifically by the number of hits (see below). Defining streak criterion based on average performance was chosen to allow comparison with the previous work described above (Gray, 2004; Gray et al., 2007), which examined the effects of streaks on attentional control, and studies of streakiness in baseball performance (Siwoff et al., 1988). These definitions should be distinguished from beliefs about streaks based on the law of small numbers, for example, the hot/cold hand or gambler’s fallacy (e.g., Gilovich, Vallone, & Tversky, 1985; Tversky & Kahneman, 1971). However, as described below, to allow for comparison with this previous literature, we also performed separate analyses with hot and cold streak classifications based on a small set of observations.

In two experiments, college players in the current study were asked to hit in a baseball batting simulation (Gray, 2002a). After adjusting the difficulty of the simulation for each batter so that all batters were performing at roughly the same level on Day 1 of the study, we measured hitting performance over an extended period on the following day. Based on this performance, batters were classified into one of three performance groups: normal, cold streak, or hot streak. Batters next completed a pressure condition in which they faced competitive and evaluative pressure. Finally, performance was evaluated over another extended period. We first examined how pressure outcome and postpressure performance varied as a function of a batter’s prepressure streak classification (Experiment 1). Next, we used secondary tasks (Gray, 2004; Castaneda & Gray, 2007) to explore to what extent these performance effects are mediated by changes in a batter’s attentional focus (Experiment 2).

### Experiment 1

#### Purpose

The goal of Experiment 1 was to examine how pressure outcome and postpressure performance varied as a function of a batter’s prepressure streak classification (normal, hot streak, or cold streak). Note that in the current study we used a “one-trial” pressure condition; therefore, success/failure under pressure was defined purely objectively (i.e., based on whether the batter got a hit in this one trial).
instead of defining it relative to an individual’s typical performance level, as is done in the majority of “choking under pressure” studies (Beilock & Gray, 2007). We chose to measure pressure in this manner as it is more representative of what batter’s face in an actual game. Our hypotheses were based on the attentional control perspective described above:

1. Batters classified in the normal or hot streak groups should have a significantly higher incidence of failing under pressure (than would be predicted based on their prepressure performance level) as compared with batters in the cold streak group. This was expected to occur because the increase in skill-focused attention associated with increased pressure (e.g., Gray, 2004) would presumably not affect batters on a cold streak, whereas it may lead to explicit monitoring for the batters in the other two streak groups.

2. Batters that fail in the pressure condition should have significantly poorer postpressure performance (than would be predicted based on their prepressure performance) as compared with those who succeed. This was expected because the former groups’ attentional focus toward skill execution would spill over into postpressure trials (Beilock & Gray, 2012), leading to impaired performance.

Participants
Thirty-six male baseball players completed the study. All participants were experienced baseball players that played for a college baseball team affiliated with the National Junior College Athletic Association (NJCAA, USA) at the time of participation. The mean age of these participants was 20.9 (SE = 0.7) and the mean number of years of competitive playing experience was 11.5 (SE = 0.4). All participants gave informed consent and the experiment was given ethics approval by the Arizona State University Institutional Review Board.

Apparatus
The baseball batting simulation used in the current study has been used in several previous experiments (e.g., Gray, 2002a, 2002b, 2004). Briefly, participants swung a baseball bat at a simulated approaching baseball. The image of the ball, a pitcher, and the playing field were projected on a 2.11 m (h) × 1.47 m (v) screen using a Proxima 6850+ LCD projector updated at a rate of 60 Hz. Mounted on the end of the bat (Rawlings Big Stick Professional Model; 84 cm [33 inches]) was a sensor from a Fastrak (Polhemus) position tracker. The x, y, z position of the end of the bat and the batter’s foot were recorded at a rate of 120 Hz. The position of the ball in the simulation was compared with the recording of bat position in real time to detect collisions between the bat and ball. Batters received auditory and visual feedback about the success of their swing (see Gray, 2002a, for details).

All simulated pitches in this study crossed the plate within the batter’s strike zone: “... area over home plate the upper limit of which is a horizontal line at the midpoint between the top of the shoulders and the top of the uniform pants, and the lower level is a line at the top of the knees” (Official Rules of Major League Baseball, 2004; p. 115). Pitches ranged in speed between 32 m/s (72 mph) and 42 m/s (95 mph). The lateral position at which pitches crossed the plate varied between 30 and 75 cm (measured from the participant’s waist). These location values correspond to pitches that would cross the inside edge and outside edges of the plate for a batter standing 30 cm from the plate.

Similar to our previous studies (e.g., Gray, 2009a), batters were asked to complete a series of “at-bats,” where an at-bat was defined as a series of pitches that continued until one of the following four performance outcomes occurred: a homerun, the ball was hit in fair play and traveled beyond the infield (designated as a successful “hit” in the current study), the ball was hit in fair play but did not travel beyond the infield (designated an “out” in the current study), or there were three strikes (i.e., the batter was called “out”). Since all simulated pitches had a trajectory that would cross the plate in the strike zone, strikes occurred when the batter did not swing, the batter hit the ball into foul territory, or when the batter swung and missed the ball. Participants were given 5 min of rest between blocks to reduce fatigue effects.

Procedure
The experiment was divided into four phases that were completed in the same order for each participant: Equalization, Prepressure, Pressure, and Postpressure. The Equalization phase was completed in a separate test session from the other three phases and the sessions were separated by one day for all participants. The details of the phases are detailed immediately below.

Equalization Phase. The goal of this phase of the experiment was to adaptively adjust the difficulty of the batting simulation so that each participant was hitting at roughly the same performance level. The desired performance level was a batting average of .500 (i.e., achieving a hit or homerun on 50% of at-bats). This level was chosen to allow for categorization of performance in the prepressure phase (see below). The difficulty of the hitting simulation was varied by increasing or decreasing the range of pitch speeds and the range of pitch crossing locations. For each batter, the simulation began with a pitch speed range of 37 ± 2 m/s and crossing location range of 52.5 ± 5 cm. These variables were then adjusted according to a staircase procedure that evaluated performance after every five at-bats (i.e., the number that would typically occur in a game). The mean speed and mean crossing location remained constant; only their ranges were altered. The rules used for changing the ranges of these variables are shown in Table 1. The staircase procedure continued until the no-change rule occurred five times in a row; that is, the batter had five...
consecutive “games” (5 sets of five at-bats) in which they hit roughly .500. The ranges used in these final five at-bats remained constant for each batter throughout the remainder of the experiment.

**Prepressure Phase.** In this phase, which began on the day following the equalization phase, batters were first given one practice at-bat to refamiliarize them with the hitting simulation. They were then asked to complete 20 at-bats with 5-min breaks in between each at-bat to avoid fatigue. Performance on these 20 at-bats was used to classify participants into one of three performance groups: cold streak (<7 hits; batting average of .300 or less), normal (>6 and <14 hits; batting average between .350 and .650) and hot streak (>13 hits; batting average of .700 or more). Participants were not informed about their group allocation during the study.

Note that a 0.20 change in batting average (i.e., the difference between the standard of 0.50 and the boundary of the hot/cold streaks groups) represents a change of approximately ±4 standard deviations from the league average for the participants in this study. These values are also similar to those used in previous research examining streaks in baseball batting (Siwoff et al., 1988); a hot streak was defined as a batting average of >.400 and a cold streak was defined as <.125 (relative to the league average of .260). Finally, it should be noted that 20 at-bats used for streak classifications (equivalent to roughly 4–5 games in baseball) is the sample size that has been used previously to examine the “hot hand” phenomenon in baseball (Siwoff et al., 1988; see also Larkey, Smith, & Kadane, 1989).

Previous research has shown that beliefs about performance streaks are typically based on relatively short samples of performance (Larkey et al., 1989). In particular, the “rule of three” (i.e., three successful outcomes or three failures in a row) appears to guide athletes’ and fans’ beliefs about whether a player is on a hot or cold streak (e.g., Köppen & Raab, 2012). Therefore, as described in the results section below, we also analyzed data based on an alternative classification scheme using the “rule of three.”

**Pressure Phase.** In this phase, batters completed one at-bat in the face of competitive and evaluative pressure. Before the at-bat, batters were read the following script:

> “Imagine you are at-bat in the 7th game of the World Series. The bases are loaded with 2-outs. If you get a hit or a home run your team will win and if you make an out your team will lose. In terms of the study, if you get a hit or a home run in this at-bat you will be entered into a draw to win $100. If you make an out you will not be entered into the draw. A group of spectators have come to watch you perform this at-bat and will cheer or boo based on how well you perform.”

As indicated in the script, a group of four confederates were brought into the laboratory and observed the batter through a window for the duration of this at-bat. Since an average cannot be calculated for a single at-bat, performance outcomes were scored as follows: homerun (3 points), hit to the outfield (2 points), groundout to the infield (1 point), strikeout (0 point). The first two outcomes were designated as “succeed” under pressure whereas the latter two were “fail” under pressure. After the at-bat, the batter was told that the completion was over and the confederates left the room. The batter then took a 10-min break before the next phase began. This pressure manipulation is similar to previous studies that have used an audience/crowd to create performance pressure (e.g., Mesagno, Harvey, & Janelle, 2011; Wang, Marchant, Morris, & Gibbs, 2004).

**Postpressure Phase.** This phase was identical to the prepressure phase except that batters did not complete the practice at-bat and instead only completed the 20 test at-bats. Before starting each phase, participants were asked to rate their level of anxiety using a 7-point Likert scale with 7 as high and 1 as low.

**Data Analysis**

Performance within each experimental phase was analyzed using one-way ANOVAs with hitting group as a between-subject factor. We next sought to determine whether the proportion of pressure outcomes (i.e., succeed vs. fail) were significantly different from what would be expected based on prepressure performance. This was achieved using the chi-square goodness-of-fit tests. To investigate the interaction between prepressure performance, pressure outcomes, and postpressure performance,

<table>
<thead>
<tr>
<th>Number of Hits (5 At-Bats)</th>
<th>Change in Speed Range</th>
<th>Change in Crossing Location Range</th>
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<tr>
<td>0</td>
<td>↓ by ±2 m/s</td>
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<tr>
<td>1</td>
<td>↓ by ±1 m/s</td>
<td>↓ by ±1 cm</td>
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<tr>
<td>2</td>
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<td>No change</td>
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<td>3</td>
<td>No change</td>
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<td>5</td>
<td>↑ by ±2 m/s</td>
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*Note. ↓ = decrease; ↑ = increase.*
a 3 × 2 × 2 mixed-factor ANOVA was used with group (Normal, Cold Streak, and Hot Streak) and pressure outcome (Succeed, Fail) as between-subjects factors and experimental phase (Prepressure, Pressure, and Postpressure) as a within-subjects factor. As a manipulation check, the anxiety ratings were submitted to a 3 × 3 mixed-factor ANOVA with group (Normal, Cold Streak, and Hot Streak) as the between-subject factor and phase (Prepressure, Pressure, and Postpressure) as the within-subject factor. Partial eta squared was used as a measure of effect size for all ANOVAs, and Cohen’s $w$ was used as a measure of effect size for chi square tests (Cohen, 1988).

**Results**

**Prepressure Phase**

Based on the 20 prepressure at-bats, 17 batters were classified as normal, 10 as cold streak, and 9 as hot streak. The mean number of hits for the three groups was as follows: normal 10.1 ($SE = 0.5$), cold streak 3.0 ($SE = 0.4$), and hot streak 15.9 ($SE = 0.5$). One-way ANOVAs revealed no significant difference in the simulation difficulty level and the batting average over the final five at-bats in the equalization phase for these three groups ($p$ both > .05)

**Pressure Manipulation Check**

Figure 1 shows the mean anxiety ratings for the normal, cold streak, and hot streak groups during the different phases of the experiment. The 3 × 3 mixed-factor ANOVA performed on these data revealed significant main effects of group, $F(2,33) = 4.57, p < .05, \eta^2_p = .22$, and phase, $F(2,66) = 70.94, p < .001, \eta^2_p = .68$. The Phase × Group interaction was not significant, $p > .5, \eta^2_p = .04$.

Examination of the main effect for phase indicated that anxiety significantly increased between prepressure and pressure, and then significantly decreased from pressure to postpressure. Examination of the main effect for group showed that the cold streak group experienced more anxiety than the hot streak group.

**Batting Performance: Pressure Phase**

The mean pressure performance scores were 1.0 ($SE = 0.2$), 2.3 ($SE = 0.28$), and 2.9 ($SE = 0.39$) for the normal, cold streak, and hot streak groups respectively. A one-way ANOVA revealed a significant effect of group on pressure outcome: $F(2,33) = 8.5, p < .001, \eta^2_p = .24$. Post hoc $t$ tests (with Bonferroni correction for type I error) revealed that performance scores in the normal group were significantly lower than for both the cold streak, $t(25) = 3.8, p < .01$, and hot streak, $t(24) = 4.5, p < .001$, groups.

Figure 2 shows the expected and observed number of succeed and fail outcomes for each group. The expected values are based on the performance in the prepressure phase. For example, the average performance for the normal group in prepressure was a batting average of 0.52; therefore, it would be expected that roughly 9 of the 17 batters in that group would succeed under pressure. Chi square tests revealed a marginally significant difference (and medium effect size) between the expected and observed values in the normal group, $\chi^2(1) = 3.8, p = .05, w = 0.3$, whereas there were no significant differences for either the cold streak or hot streak groups ($p$ both > .1). There was, however, a medium effect size ($w = 0.35$) for the difference between observed and expected outcomes for the cold streak group.

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**Figure 1** — Mean anxiety ratings for the different phases of the experiment. Ratings were made at the start of each phase before batting. Note the ratings in the pressure phase were made after the participant was read the instructions. Error bars are standard errors.
Figure 2 — Expected and observed number of batters that succeeded and failed under pressure for the three performance groups.
Postpressure Phase

The mean number of hits in the postpressure phase was 8.3 (SE = 1.1), 7.8 (SE = 1.5), and 14.1 (SE = 0.9) for the normal, cold streak, and hot streak groups respectively. A one-way ANOVA revealed a significant effect of group on the number of hits in the postpressure phase, $F(2,33) = 7.6, p < .01, \eta^2_p = .22$.

However, further analysis of the data revealed that performance on the postpressure phase was highly dependent on the outcome of the pressure phase. Figure 3 shows the mean number of hits in the pre- and postpressure phases for the normal, cold streak, and hot streak groups, separated for batters that had a successful outcome in the pressure phase and those who failed under pressure. It is clear from this figure that batters who succeeded under pressure (particularly those classified as normal or cold streak) performed better in the postpressure phase as compared with those that failed under pressure. The $3 \times 2 \times 2$ mixed-factor ANOVA performed on these data revealed a significant three-way interaction between group, pressure outcome, and experimental phase: $F(2, 30) = 5.60, p < .01, \eta^2_p = .27$. To interpret this interaction, we looked at the relationship between pressure outcome and experimental phase for the three different groups separately.

For the normal group, a $2 \times 2$ ANOVA on number of hits revealed a significant main effect for pressure outcome, $F(1,15) = 6.80, p < .05, \eta^2_p = .31$, and a significant Pressure Outcome × Phase interaction, $F(1,15) = 32.8, p < .001, \eta^2_p = .69$. The main effect of phase was not significant ($\eta^2_p = .003$). Tukey’s HSD tests ($p < .05$) revealed that participants who failed under pressure subsequently performed significantly worse, whereas the performance for participants who succeeded under pressure significantly improved.

For the cold streak group, the $2 \times 2$ ANOVA on number of hits revealed a significant main effect for pressure outcome, $F(1,8) = 8.94, p < .05, \eta^2_p = .53$, and a significant main effect for phase, $F(1,8) = 29.3, p < .01, \eta^2_p = .79$. These main effects were superseded by a significant Pressure Outcome × Phase interaction, $F(1,8) = 16.5, p < .01, \eta^2_p = .67$. Tukey’s HSD tests showed that performance for participants who succeeded under pressure significantly improved, whereas performance for participants who failed under pressure remained unchanged.

For the hot streak group, no significant main effects were found for pressure outcome or phase ($p$ both $> .25, \eta^2_p$ both $< .2$). In addition, the Pressure Outcome × Phase interaction was not significant ($p > .5, \eta^2_p = .04$). Taken together, the results for this ANOVA indicate that performance for the hot streak group remained unchanged after pressure.

As an additional means of analyzing the effect of pressure outcome on postpressure performance, we used chi square tests to determine whether the observed number of hits was significantly different than the expected number of hits (calculated as described above) for each group. For the normal group, both batters who succeeded, $\chi^2(1) = 3.8, p = .05, w = 0.3$, and batters who failed, $\chi^2(1) = 3.8, p = .05, w = 0.3$, under pressure had marginally significant differences between expected and observed outcomes. As indicated by the $w$ values, both of these comparisons had medium effect sizes. For the cold streak group, batters who succeeded had a significantly greater number of hits than expected, $\chi^2(1) = 19.2, p <
.001, \( w = 0.7 \), while batters who failed had no significant difference \((p > .5, w = 0.09)\). Finally, for the hot streak group, for both batters who succeeded and those who failed, there were no significant differences between the expected and observed number of hits \((p \text{ both } > .2, w \text{ both } < 0.15)\).

Alternate Analysis: Rule of Three

Instead of classifying participants based on their number of hits (out of 20 at-bats) in the prepressure phase we used the final three at-bats. The groups were defined as cold streak (three consecutive outs), hot streak (three consecutive hits), and normal (all other outcomes). When classified in this manner, there were 18, 9, and 9 batters in the normal, cold streak, and hot streak groups respectively. The correlation between the batter classification based on 20 at-bats and the classification based on the final 3 at-bats was positive but not significant \((r = .28, p > .2)\). The analysis using this alternative classification produced a very different pattern of results, as there were no significant relationships between batting group and performance under pressure and performance postpressure. One-way ANOVAs revealed that both pressure score \((p > .5, \eta^2_p = 0.1)\) and pressure outcome \((p > .1, \eta^2_p = 0.16)\) were not significantly related to batting group. Performance in the first three at-bats of the postpressure phase was analyzed using a two-way ANOVA with batting group and pressure outcome as between-subjects factors. Only the main effect of pressure outcome was significant, as batters who succeeded under pressure performed better in the first three at-bats postpressure compared with those who failed, \(F(1,30) = 13.1, p < .01, \eta^2_p = 0.51\). Neither the main effect of batting group \((p > .05)\) nor the batting Group \(\times\) Pressure Outcome interaction \((p > .5)\) were significant.

Correlations With League Batting Average

In previous studies we have reported that several aspects of batting performance in the simulation used in the current study have been significantly correlated with player’s batting averages from the last full season of actual league play (Gray, 2002a, 2004, 2010, in press). These findings suggest that the simulation has good external validity. In the current study, there was a significant positive correlation between league batting average (over the last full season of play) and the final difficulty level in the equalization phase \(i.e., \text{the range of pitch speeds and crossing locations}: r = .41, \(t(34) = 2.6, p < .01\)\). In other words, as expected, better hitters could achieve an average of .500 in the simulation with a wider range of pitch trajectories as compared with less-skilled hitters. As the goal of varying the difficulty level for each participant was to minimize the effect of any skill-level differences between players, we did not expect any significant correlations in the other phases of the experiment. Indeed, league batting average was not significantly correlated with the number of hits in the prepressure phase \((r = .27, p > .1)\), the pressure outcome \((r = .23, p > .1)\), or the number of hits in the postpressure phase \((r = .19, p > .2)\).

Discussion

The goal of the Experiment 1 was to investigate the interactions between performance streaks and performance under pressure. The results suggest there is a strong relationship as two different types of effects were found. First, whether batters succeeded or failed under pressure was significantly related to their performance history immediately before the pressure event \(i.e., \text{whether they were on a hot or cold streak}\). Second, performance postpressure was significantly related to both the pressure outcome and prepressure performance. We next consider these two effects in detail.

The Effect of Prepressure Performance on Success Under Pressure

Based on an attentional control perspective, it was predicted that the negative effects of pressure would be greatest for the normal and hot streak groups, whereas the performance for the cold streak group would be relatively unaffected. The hypothesis was based on our previous report that batters on a cold streak focus their attention on skill execution, whereas batters performing at their normal level or above do not (Gray, 2004). If, as proposed by many \(e.g., \text{Baumeister, 1984; Beilock & Carr, 2001},\) choking under pressure is caused by a shift to skill-focused attention, one would expect that this would only occur in the normal and hot streak groups \(i.e., \text{pressure cannot induce skill-focused attention when it is already occurring}\).

The results of the current study only partially supported this hypothesis. As predicted, batters in the normal group were more negatively affected by the introduction of pressure as compared with batters in the cold streak group. As can be seen in Figure 2, the observed number of batters who failed under pressure was higher than would be expected \(based \text{on prepressure performance}\) for the normal group and lower than expected for the cold streak group. Furthermore, batting scores under pressure were significantly higher for the cold streak group than for the normal group. As described above, we propose that the difference between these two groups was due to a difference in the attentional control structures supporting performance.

Unexpectedly, however, the pressure manipulation did not have a significant effect on performance for the hot streak group. As can be seen in Figure 2, the observed number of failures under pressure was exactly as would be predicted based on prepressure performance. Furthermore, this group had the highest mean performance score under pressure. It is unlikely that this effect was due to a difference in skill level between batters in these two groups as we attempted to minimize this difference by adjusting the difficulty of the simulation for each
batter—an effort that seems to have been successful given that there were no significant differences in batting average between the groups for the final part of the equalization phase and no significant correlations with league batting average.

The present findings suggest that a hot streak somehow insulates a performer against the effects of pressure. What might cause this effect? One possibility is that the difference in performance under pressure for the hot streak and normal groups in the current study was mediated by a psychological variable that was not measured. In particular, research on the phenomenon of psychological momentum has shown that a series of successful performances are associated with changes in confidence, energy, effort, optimism, and focus (Vallerand, Colavacchio, & Pelletier, 1988). In addition, recent research has shown perceived control to be a strong predictor of performance in pressure situations (Cheng, Hardy, & Woodman, 2011). It will be interesting for future studies to use questionnaire measures to evaluate some of these other variables.

Alternatively, batters on a hot streak could have a different focus of attention than batters performing near their normal level. For example, it is possible that batters on a hot streak focus their attention on an effect of their movement that is a larger distance from the body (e.g., the ball flying leaving the bat) while “normal” batters focus their attention on an effect that is closer to their body (e.g., the movement of their bat). As first demonstrated in a balancing task by McNevin, Shea, and Wulf (2003), performance increases as the distance between the body and the focus of attention increases. McNevin and colleagues proposed that this effect occurs because in the latter case, it is less likely a performer will attend to his or her body movement and actively intervene with skill execution (resulting in a disruption of automaticity).

In a baseball context, we have provided evidence consistent with this proposal (Castaneda & Gray, 2007). We found that the timing of error of the swing was significantly higher (by roughly 75%) when expert batters were asked to perform a secondary task that involved judging the movement of their bat as compared with when they were asked to perform a secondary task that involved judging the direction the ball traveled as it left the bat. Extending these distance effects to performance under pressure, it seems reasonable to hypothesize that it is less likely that a batter will shift their attention to skill execution under pressure when their focus is at a distance further from their body. We explore this possibility directly in Experiment 2 through the use of secondary tasks.

**Effects of Pressure Outcome and Prepressure Performance on Postpressure Performance**

Based on the attentional “spillover” effects we reported in a recent secondary task experiment (Beilock & Gray, 2012), it was predicted that batters who fail under pressure would have significantly worse performance postpressure (due to residual skill-focused attention) as compared with those who succeed under pressure. The results again only partially supported this hypothesis. Although batters who succeeded under pressure did have significantly more hits postpressure than batters who failed, this effect was qualified by a significant Prepressure Performance × Pressure Outcome interaction. As shown in Figure 3A, batters in the normal group had a significant increase in number of hits from pre- to postpressure when they succeeded under pressure and a significant decrease when they failed. These changes were both larger than would be expected based on their prepressure performance. The decline in performance after a failure is consistent with the attentional spillover proposal described above.

The postpressure results for the cold streak and hot streak groups were not as expected, however. Batters in the cold streak group who succeeded under pressure showed a significant increase in batting performance pre- to postpressure that was significantly larger than would be expected on the basis of their prepressure performance. In other words, succeeding under pressure served to break them out of their cold streak. For the hot streak group, there was no significant effect of pressure outcome on postpressure performance. The lack of improvement from pre- to postpressure for the succeed group could be due to a ceiling effect, whereas the lack of significant change for the fail group was most likely due to the fact that there were only two batters who fell into this category. Again, we explore the role of attentional focus in these effects in more detail in Experiment 2.

**Long Performance Streaks Versus “The Rule of 3”**

As discussed above, the perception that an athlete is on a “hot streak” (by both fans and teammates) appears to be based on the previous two or three performance outcomes rather than on a longer-term assessment of performance. Consequently, three outcomes has been the most common unit of analysis in research on performance streaks (Bar-Eli, Avugos, & Raab, 2006). When the data in the current study were analyzed in terms of the three outcomes before and three outcomes after the pressure event, a very different pattern of results was observed. In particular, at this level of analysis, there were no longer significant relationships between prepressure performance and pressure outcome and prepressure performance and postpressure performance. The implications of this finding are discussed in detail below.

**Experiment 2**

**Purpose**

In Experiment 1, the observed relationship between performance pressure and performance streaks was only partially consistent with our predictions based on the attentional control perspective. The goal of Experiment
Institutional Review Board.

Participants
Twenty baseball players completed the study. All participants were experienced baseball players who played for a college baseball team affiliated with the National Junior College Athletic Association (NJCAA, USA) at the time of participation. None of the participants completed Experiment 1. The mean age of these participants was 21.7 (SE = 0.9), and the mean number of years of competitive playing experience was 12.2 (SE = 0.6). All participants gave informed consent, and the experiment was given ethics approval by the Arizona State University Institutional Review Board.

Apparatus and Procedure
The apparatus and procedure used in Experiment 2 were identical to those of Experiment 1 except for the following. In Experiment 2, batters were asked to perform secondary tasks while batting in all phases of the experiment. These tasks involved a combination of the tasks developed by Gray (2004, Experiment 2) and Castaneda & Gray (2007). Briefly, during the first 8 s of each trial, a probe (a small yellow cone) was displayed on the field. The probe, used for the “ball” secondary task described below, was always located at the bottom of the screen but its lateral position was varied randomly from trial to trial. At a random time between 300 and 800 ms after the virtual ball appeared on the screen, a single auditory tone was presented for a duration of 80 ms. The frequency of the tone was either 250 or 500 Hz and was randomly chosen from trial to trial. The batter was not required to respond to the cone probe or the auditory tone during their swing but instead received a text prompt after the swing (and hitting feedback) was completed. There were four different prompts: “none,” “frequency,” “bat,” and “ball.” For trials in which the “frequency” prompt appeared, the participant’s task was to signal the tone frequency by saying “high” or “low.” For trials in which the “bat” prompt appeared, the participant’s task was to signal whether the bat was moving downward or upward relative to the instant the tone was presented by saying “up” or “down.” For trials in which the “ball” prompt appeared, the participant’s task was to judge whether the simulated ball traveled to the right or to the left of the probe location shown in the preswing interval by saying “left” or “right.” Response time was not measured. For the “none” prompt, batters were informed that they did not need to make any response. The proportion of “none,” “frequency,” “bat,” and “ball” prompts was 0.1, 0.3, 0.3, and 0.3, respectively, and presentation was randomized. For trials in which the batter did not make contact with the ball and a “ball” prompt had been randomly selected, the prompt was switched to “none.” Using these data, we calculated the percentage accuracy for the “frequency,” “bat,” and “ball” secondary tasks in each of the phases of the experiment.

Data Analysis
To examine the effectiveness of the pressure manipulation, we submitted the anxiety data to a 3 × 3 mixed-factor ANOVA with group (Normal, Cold Streak, and Hot Streak) as the between-subject factor and phase (Pre-pressure, Pressure and Post-pressure) as the within-subject factor. Performance in the pressure and postpressure phases was analyzed using separate one-way ANOVAs with hitting group as the between-subject factor. An independent samples t test was employed to compare the performance in the postpressure phase between different pressure outcomes (i.e., Succeed vs. Fail).

The percentage accuracy data for both the bat and the frequency secondary tasks were submitted to separate 3 × 3 mixed-factor ANOVAs with group (Normal, Cold Streak, and Hot Streak) as the between-subject factor and phase (Equalization, Pressure and Post-pressure) as the within-subject factor. Significant effects were broken
down using Tukey’s HSD post hoc procedures ($p < .05$). After initial inspection of the data, it was determined that the percentage accuracy for the secondary task of judging the direction of ball travel was not reliable for batters in the cold streak group due to a large number of trials in which batters in this group made no contact with the ball. For the normal and hot streak groups, the difference between trials in which no contact was made with the ball was not significant ($p > .05$). Therefore, the percentage accuracy for the ball secondary task data were submitted to a $2 \times 3$ mixed-factor ANOVA with group (Normal and Hot Streak) as the between-subject factor and phase (Equalization, Pressure and Postpressure) as the within-subject factor.

### Results

#### Prepressure Phase

Based on the 20 prepressure at-bats, 10 batters were classified as normal, 5 as cold streak, and 5 as hot streak. The mean number of hits for the three groups was as follows: normal 9.8 ($SE = 0.6$), cold streak 2.6 ($SE = 0.7$), and hot streak 15.8 ($SE = 0.8$). One-way ANOVAs revealed no significant difference in the simulation difficulty level and the batting average over the final 5 at-bats in the equalization phase for these three groups ($p$ both $> 0.1$).

#### Pressure Manipulation Check

The ANOVA conducted on the anxiety data revealed a significant main effect for phase, $F(2,34) = 23.6, p < .001$, $\eta^2_p = .58$; a nonsignificant main effect for group, $F(2,17) = .11, p = .90, \eta^2_p = .01$, observed power = .06; and a nonsignificant Phase $\times$ Group interaction, $F(4,34) = 1.04, p = .40, \eta^2_p = .11$, observed power $= .29$. Examination of the main effect for phase indicated that anxiety significantly increased between prepressure ($M = 2.0, SE = 0.2$) and pressure ($M = 4.0, SE = 0.2$), and then significantly decreased from pressure to postpressure ($M = 2.3, SE = 0.2$).

#### Batting Performance: Pressure and Postpressure

The mean performance scores in the pressure phase were 0.9 ($SE = 0.28$), 1.4 ($SE = 0.4$), and 2.4 ($SE = 0.4$) for the normal, cold streak, and hot streak groups respectively. The one-way ANOVA revealed a significant effect of group on the performance scores for the pressure phase, $F(2,17) = 4.79, p = .022, \eta^2_p = .36$. Breakdown of this main effect revealed that the hot and cold streak groups performed significantly better than the normal group under pressure.

We again calculated the percentages of batters that were expected to succeed under pressure for each group based on prepressure performance and compared them to the observed number of successes (as described above). These values were as follows (expected, observed): normal (59%, 30%), cold streak (20%, 60%), and hot streak (79%, 80%). The pattern of results is highly similar to what was observed in Experiment 1 (Figure 2); namely, the normal group did poorer under pressure than expected whereas the cold and hot streak groups performed at or above the expected level. We could not analyze this effect statistically, however, due to the smaller $n$ in Experiment 2.

The mean number of hits in the postpressure phase was 7.5 ($SE = 1.5$), 8.2 ($SE = 1.5$), and 14.0 ($SE = 1.1$) for the normal, cold streak, and hot streak groups respectively. The one-way ANOVA revealed a significant effect of group on the number of hits in the postpressure phase, $F(2,17) = 4.81, p = .022, \eta^2_p = .36$. Breakdown of this main effect revealed that hot group obtained more hits in the postpressure phase than the normal group. An independent samples $t$ test comparing postpressure performance based on their pressure outcome (e.g., fail vs. succeed) revealed a significant difference in postpressure hits between those who failed ($M = 5.9, SE = 1.1$) and those who succeeded ($M = 12.7, SE = 0.9$) under pressure, $t(18) = –4.8, p < .001$.

Figure 4 shows the mean number of hits in the pre- and postpressures for the normal, cold streak, and hot streak groups separated for batters that had a successful outcome in the pressure phase and those that failed under pressure. The pattern of results is highly similar to what was found in Experiment 1 (Figure 3). Due to the small $n$ in some of the outcome groups, we could not evaluate these effects statistically, however.

#### Secondary Task Performance

##### Bat Judgment.

The mean percentage correct scores for the secondary task that involved judging the direction of bat travel are shown in Figure 5A. The $3 \times 3$ mixed-factor ANOVA performed on these data revealed a nonsignificant main effect for phase, $F(2,34) = .71, p = .50, \eta^2_p = .04$; a nonsignificant main effect for group, $F(2,17) = 2.37, p = .12, \eta^2_p = .22$; but a significant Phase $\times$ Group interaction, $F(4,34) = 3.61, p = .015, \eta^2_p = .30$. Breakdown of this interaction revealed that secondary task accuracy for the hot streak group significantly decreased between the equalization and prepressure phases. In addition, batters in the cold streak group were significantly better at making this judgment in the prepressure phase than batters in both the hot streak group and the normal group.

##### Frequency Judgment.

The mean percentage correct scores for the secondary task that involved judging tone frequency are shown in Figure 5B. The mixed-factor ANOVA performed on these data revealed nonsignificant effects for phase, $F(2,34) = .84, p = .44, \eta^2_p = .05$, observed power $= .18$; group, $F(2,17) = 1.83, p = .19, \eta^2_p = .18$, observed power $= .33$; and the Phase $\times$ Group interaction, $F(4,34) = 1.83, p = .15, \eta^2_p = .18$, observed power $= .50$.
Figure 4 — Mean number of hits in the pre- and post-pressure phases as a function of group and pressure outcome in Experiment 2. Error bars are standard errors.

Figure 5 — Mean percent correct responses for the “bat” (A), “frequency” (B), and “ball” (C) secondary tasks in the different phases of the Experiment 2. Error bars are standard errors.
**Ball Judgment.** The mean percentage correct scores for the secondary task that involved judging the direction the ball traveled as it left the bat are shown in Figure 5C. The 2 × 3 mixed-factor ANOVA performed on these data revealed a nonsignificant effect for phase, \(F(2,26) = 1.38, p = .27, \eta^2_p = .10\), and a significant effect for group, \(F(1,13) = 9.16, p = .01, \eta^2_p = .41\). However, these effects were superseded by a significant Phase × Group interaction, \(F(2,26) = 6.2, p = .006, \eta^2_p = .32\). Breakdown of this interaction using Bonferroni post hoc tests revealed that secondary task accuracy for the hot streak group significantly increased between the equalization and prepressure phases, whereas the normal groups’ accuracy remained the same until it decreased between the prepressure and postpressure phases.

To further analyze the effects of pressure on attentional focus, we compared the percentage accuracy in the postpressure phase for batters who succeeded and failed under pressure. In the postpressure phase, players who failed under pressure had significantly greater accuracy for the bat secondary task as compared with players who succeeded (79.6% vs. 73.2%, \(t(9) = 3.6, p < .001\)), had significantly lower accuracy in the frequency secondary task compared with players who succeeded (76.6% vs. 82.5%, \(t(9) = 3.1, p < .01\)), and had significantly lower accuracy in the ball secondary task compared with players who succeeded (81.6% vs. 88.9%, \(t(9) = 3.2, p < .01\)).

### Discussion

Using a new group of batters, two of the primary effects observed in Experiment 1 were replicated: (1) batters in the normal group performed significantly worse under pressure as compared with batters in the cold and hot streak groups and (2) batters who succeeded during the one at-bat pressure phase performed significantly better in the postpressure phase as compared with those that failed under pressure. We next consider the potential relationship between these performance effects and changes in the attentional focus of batters.

Consistent with our prediction and our previous findings (Gray, 2004), batters who had the worst performance in the prepressure phase (i.e., the cold streak group) were significantly more accurate in the secondary task that involved attending to skill execution (the movement of their bat), as compared with batters performing at an “average” level (the normal group) and batters who had the best performance (the hot streak group). This occurred despite the fact that there was no significant difference in secondary task accuracy during the equalization phase for these groups. This finding suggests that batters in the cold streak group had a more inward attentional focus as compared with batters in the other two groups in the prepressure phase. We would again propose that this inward shift of attention reflects an error-correcting strategy used by the cold streak group. As a test of this hypothesis, we split the at-bats in the prepressure phase in half and compared the accuracy for bat judgment secondary task for the two halves. For the cold streak, a pairwise t test revealed that accuracy was significantly higher in the second 10 at-bats as compared with the first 10, \(t(4) = 3.2, p < .05\), suggesting that the poor performance induced the shift in attentional focus.

This comparison was not significant for the other two performance groups (\(p\) both > 0.2). As proposed by Gray (2004), we would argue that batters in the normal and hot streak groups were relatively inaccurate at the bat judgment task and did not show a change in accuracy from the first to second half of the prepressure block because (1) skilled performers are known to normally use an external focus of attention (reviewed in Wulf & Prinz, 2001) and (2) there would be no incentive to shift their attentional focus because they were performing at or above their normal level.

Given that batters in the cold streak group were already focusing their attention on skill execution before the pressure phase, they should be less affected by the tendency for pressure to induce an inward shift of attention. We propose that this explains why batters in the normal group exhibited a significant decline in performance in the pressure conditions (30% success rate across the two experiments) whereas the cold streak group did not (60% success rate across the two experiments); the former group exhibited an explicit monitoring effect while the latter did not. Because we wanted to use a pressure test more relevant to the sport of baseball (one at-bat), we could not assess attentional focus during the pressure phase of the current study. In our previous work, however, we found that batters who failed under pressure exhibited a significant increase in the accuracy for the task of judging the direction of bat movement (Gray, 2004; Experiment 3). Therefore, we feel it is reasonable to assume that this also occurred for the normal group in the current study; however, this should be confirmed in future studies.

This difference in skill-focused attention in the prepressure phase cannot explain the relative performance of the normal and hot streak groups in the pressure phase, however. Since, like the normal group, the batters in the hot streak group were relatively inaccurate for the skill-focused bat judgment task in the prepressure phase, it might be expected that they would also be susceptible to explicit monitoring under pressure. Our results suggest this clearly was not the case as batters in the hot streak group excelled under pressure (79% success rate across the two experiments) and scored significantly higher than batters in the normal group in both experiments.

We propose that this effect was most likely related to the fact that during the prepressure phase batters in the hot streak group were attending more to the outcome of their swing as compared with batters in the normal group. As shown in Figure 5C, batters in the hot streak group were significantly more accurate in judging the direction the ball was traveling as it left the bat as compared with batters in the normal group. This finding is consistent with one of main results reported in Castaneda...
and Gray (2007): when expert batters’ attention was directed to the ball leaving the bat (via a blocked design in which players were required to make this judgment on every trial), batting performance was significantly higher as compared with other secondary task conditions (judging tone frequency or bat movement) and compared with a control condition in which no attentional instructions were given. Since manipulations that focus a performer’s attention on the outcome of an action have been shown to insulate a performer against the effects of pressure (e.g., Bell & Hardy, 2009; Land & Tenenbaum, 2012), we propose that a similar effect occurred in the current study. Namely, the attentional focus on swing outcome in the hot streak group prevented explicit monitoring under pressure—this possibility along with alternative explanations is discussed in more detail below.

As predicted, the outcome in the pressure phrase had a significant effect on the postpressure attentional focus adopted by batters. In the postpressure phase of Experiment 2, batters who failed under pressure were significantly more accurate in the skill-focused task of judging bat movement and significantly less accurate in ball and frequency secondary tasks. We propose that this effect was due to attentional spillover (Beilock & Gray, 2012); the attentional focus on bat movement induced by pressure for batters who failed in the pressure phase continued into the postpressure phase. Due to the smaller n in Experiment 2, we could not further subdivide postpressure effects by streak group. Therefore, it will be important for future research to investigate how a performer’s attentional focus postpressure depends on the combination of streak and pressure outcome (as observed in Experiment 1 of the current study).

**General Discussion**

**Performance Streaks, Pressure, and Attentional Focus**

The goal of the current study was to investigate the relationship between streaks in performance, performance under pressure, and the attentional focus adopted by a performer. Performance history was found to have a significant influence on the ability of our participants to succeed under competitive and evaluative pressure. Batters entering the pressure situation following a run of exceptionally poor performance (i.e., a cold streak) or a streak of exceptionally good performance (i.e., a hot streak) had a hitting success rate under pressure that was at (or even slightly above) the level that would be predicted based on prepressure performance. In other words, “streaky” hitters in our study were not affected by pressure. In contrast, batters entering the pressure situation performing near the typical/average level of performance defined for our study (i.e., the normal group) had a hitting success rate that was significantly lower than would be expected based on prepressure performance. In other words, they “choked” under pressure.

Previous research has identified several factors that can influence how well a performer handles pressure, including level of expertise (e.g., Beilock, Carr, MacMahon & Starkes, 2002) and disposition for reinvestment (Masters, Polman, & Hammond, 1993). These variables have recently been incorporated into a structural equation model to predict performance under pressure (Otten, 2009). The present results suggest that such models of performance under pressure need to also take into account performance history (streaks).

By measuring performance for an extended period postpressure, the current study also addressed an important question that has been somewhat overlooked in previous research: how does succeeding or failing under pressure influence subsequent performances in nonpressure conditions? In the current study, the outcome of the one pressure at-bat was a very strong predictor of how well batters performed in 20 following nonpressure at-bats. Across the two experiments, batters who succeeded under pressure had a postpressure batting average that was 32 percentage points higher than batters who failed (mean batting averages of .632 vs. .314). This effect was again qualified by batters’ performance history prepresure, however.

An interesting way to visualize the relationship between prepressure performance, pressure outcome, and postpressure performance is to examine how the streak classifications changed from pre- to postpressure in our study. Figure 6 shows the proportion of batters (combined across the two experiments) in each streak group in the postpressure phase. For batters classified in the normal group (prepressure) who failed in the pressure at-bat, the majority suffered a cold streak postpressure. Conversely, for batters in normal group who succeeded under pressure, the majority went on a hot streak postpressure. For batters classified as cold streak (prepressure), the majority who failed under pressure remained on a cold streak postpressure whereas the majority who succeeded returned to the normal performance classification they exhibited in the first (equalization) phase of the study. Finally, for batters classified as being on a hot streak (prepressure), the majority who failed under pressure remained on a hot streak postpressure whereas the majority who succeeded remained on a hot streak. Clearly, the outcome of a high-pressure situation can have a profound effect on what happens afterward when the pressure is removed.

Given that one of the means by which pressure has been proposed to cause performance failures is through changes in the performer’s attentional focus (e.g., Baumeister, 1984; Beilock & Carr, 2001), we hypothesized that similar mechanisms could explain these relationships between performance streaks and pressure outcomes. In particular, since the attentional focus of baseball batters has been shown to be linked to performance history in previous research (e.g., Gray, 2004; Gray, Beilock, & Carr, 2007), we predicted that batters in the different streak groups of the current study would have different attention foci when entering the...
pressure at-bat. In addition, since the use of secondary tasks designed to shift a performer’s attention has been shown to influence performance under pressure (e.g., Jackson et al., 2006; Lewis & Linder, 1997), we expected that the differences in attentional focus when entering the pressure at-bat phase would cause different responses to pressure.

The results from Experiment 2 generally support this line of reasoning. Consistent with Gray (2004), batters who were on a cold streak before the pressure situation exhibited higher levels of skill-focused attention than those who were either on a hot streak or performing at a normal level. Performance differences between the hot streak and normal groups were qualified by opposing differences between the degree to which they focused on the outcome of their movement, or focused on the bodily execution of the movement. Specifically, the hot streak group were found to be more focused on the outcome

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**Figure 6** — Proportion of batters in each streak category as a function of pressure outcome. Data are combined for Experiment 1 and 2.
of their swing and less focused on the execution of their swing than the normal group. When taken together, the relationships between performance and direction of attention found in the current study support the viewpoint that focusing away from task execution allows greater automaticity of proceduralized skills (e.g., Beilock et al., 2002; Gray, 2004). Furthermore, when attention is directed toward the environment and thus a larger distance away from skill execution (as for the hot streak group), performance is improved still further (e.g., Castaneda & Gray, 2007; McNevin et al., 2003). These prepressure differences in performance and focus of attention also influenced the groups’ subsequent performance responses to pressure.

Batters categorized into the normal group performed substantially worse in the pressure condition than was expected based on their prepressure performance (i.e., they choked). As stated above, previous research has shown that similar choking effects in expert batters were associated with inward shifts of attention as predicted by the explicit monitoring theory of choking (Gray, 2004; Experiment 3). Accordingly, we suggest that this is also the most parsimonious explanation for the choking effect in the current study. This explanation is further supported by the finding that batters on a cold streak did not exhibit choking effects. Specifically, as it has been shown that the cold streak group were already focusing on their movement, so one would not expect pressure to induce an inward focus of attention, as this was already occurring. This finding leads to some interesting practical implications that are expanded upon below. Somewhat surprisingly, the hot streak group did not show any evidence of choking under pressure, even though they should be susceptible to the effects of explicit monitoring.

The lack of performance decrements under pressure for the hot streak group, who were focusing on the outcome of their action in the prepressure phase, suggests that this form of attentional focus may attenuate pressure effects. This finding is in line with previous research showing that the use of secondary tasks (or related manipulations such as “quiet eye” training) that direct attention away from movement execution have been robustly shown to reduce the effect of pressure on performance (Jackson et al., 2006; Land & Tenenbaum, 2012; Lewis & Linder, 1997; Mesagno, Marchant, & Morris, 2009; Vine, Moore, & Wilson, 2012). Of particular relevance to the current study, Bell and Hardy (2009) examined the chip shot performance of skilled golfers when adopting three different foci of attention, in both baseline and anxiety-inducing conditions. They found that performance was significantly better in both conditions when a distal external focus of attention (i.e., focusing on the flight of the ball) was adopted, in comparison with both a proximal (i.e., focus on the clubface position throughout the swing) and internal focus (i.e., focus on the swing of the arms). Therefore, it seems adopting a focus of attention toward the outcome of an action may serve to prevent choking under pressure, either when this shift of attention is instigated or occurs spontaneously. This is particularly important as it offers athletes a relatively simple and ecologically valid method to prevent choking under pressure.

There are some alternative explanations for the performance of the hot streak group in our study that should be considered. First, it is possible that the hot streak group in the current study performed better under pressure than the other two groups because their load was lower. Although this effect could have contributed to present results, we would argue that it is unlikely that this occurred for all batters in the hot streak group and across two separate experiments. Furthermore, a similar explanation could be applied to the cold streak group, whose performance did not remain poor across the different phases.

Another possibility is that the observed differences in performance between groups reflect differences in working memory load rather than attentional focus effects. Since it has been shown that working memory load is reduced during streaks of good performance (Poolton, Maxwell, Masters, & Raab, 2006), it is possible that the hot streak group in the current study performed better under pressure than the other two groups because their load was lower. Although this effect could have contributed to present results, we would argue that it is unlikely to have been the primary factor. If it were the case that there were no differences in direction of attention between groups and the working memory load of the hot streak group was simply higher, then the hot streak group should have performed significantly better on all of the secondary tasks. As can be seen in Figure 5B, this was not the case as the hot streak group had a significantly lower accuracy in the bat judgment task as compared with the other groups. However, it will be important to future research to investigate the relative contribution of these two effects by comparing secondary tasks that are designed to shift attention to particular locations (as used in the current study) versus those designed to increase working memory load (e.g., counting backward by threes).

The result achieved in a pressure situation was associated with both attentional and performance changes after the pressure situation. Specifically, failure under pressure in Experiment 2 led to the adoption of skill-focused attentional focus and poorer performance after the pressure situation. This finding dovetails well with recent research showing that the effects of skill-focused attentional manipulations can spill over into successive performances (Beilock & Gray, 2012). In the current study, it seems that failure under pressure was caused by a pressure-induced inward focus of attention as predicted by the explicit monitoring theory. This inward focus of attention then continued after the pressure event and caused an extended period of inferior performance when compared with their prepressure level. It may be useful for athletes to be aware of such attentional changes after
failing under pressure to help prevent an extended period of poor performance that could be even more detrimental to their confidence.

Implications for “Hot Hand” Research

Given that performance streaks are a major focus of the current study, it is interesting to consider how our findings relate to the most famous and contentious topic in this area: the “hot hand” phenomenon. The crux of the debate surrounding the hot hand is not whether streaks of performance occur in sports—no one would argue they do not (see, for example, Connolly & Rendleman, 2008)—but rather whether these streaks have any influence on the next performance outcome, such as whether hitting three shots in a row in basketball increases the likelihood that the player will hit his or her next shot (Gilovich et al., 1985). Within the sport of baseball, the vast majority of studies have found no evidence to support the idea of a hot-hand effect because batting averages are just as likely to be higher following cold streaks as following hot streaks (e.g., Siwoff et al., 1988; reviewed in Bar-Eli et al., 2006).

The goal of the current study was not to investigate the traditional hot hand phenomenon but rather to extend it into a novel domain: performing under pressure. Even though, particularly in the sport of baseball, there is little evidence to suggest that hot or cold streaks influence performance when the context stays the same, the current study provides initial evidence that they may have a significant influence on performance outcomes when the context changes to a high-pressure situation. It will be interesting for future research to investigate whether a similar pattern can be observed from game data. For example, is the batting average in “walk-off” situations (i.e., if the batter gets a hit, their team will win the game) higher for batters on a hot streak as compared to a cold streak? Or is a soccer player more likely to make a penalty kick in a shootout when they have scored a non-shootout goal in each of their past few games as compared to when they have gone scoreless?

Practical Implications

The results of the current study provide evidence that streaks of performance influence how well an athlete will respond to a pressure situation: batters on hot or cold streaks are relatively more effective under pressure as compared with batters performing at their typical level. This has an important yet counterintuitive implication for coaches: while it may be tempting to remove a player on a cold streak from a high-pressure situation (e.g., not select them as one of the kickers in a penalty shootout in soccer, or pinch hit for them in the ninth inning in a baseball game), the present findings suggest that such players may perform better under pressure than a non-streak player. In terms of players on a hot streak, the present findings suggest that a coach should favor such individuals for a high-pressure situation but only if the assessment of streakiness is based on a large enough sample. Again running somewhat counterintuitive to common belief, our findings suggest that streaks based on three outcomes (i.e., the current game’s performance in many sports) are not predictive of how well athletes will perform under pressure. It will be interesting to see whether these effects are observed in other sports and using a larger number of athletes.

The other main finding of the current study is that performance following a high-pressure situation is influenced by the interaction between prepressure performance and pressure outcome. Consistent with many famous examples of choking, the present results show that a single incidence of failing under pressure can result in a dramatic decline in performance postpressure. This again appears to be particularly true for batters not on a streak before the pressure event. Conversely, a single success under pressure can elevate the performance postpressure. In particular for performers on a cold streak, the present findings suggest that succeeding under pressure can be a “cold streak breaker.” Combined with the finding described above, this implies that it may be a good coaching strategy to put an athlete on a cold streak into high-pressure situations as much as possible: our results suggest they are more likely to succeed than non-streak batters and if they do succeed it is likely to result in improved performance postpressure. It will be interesting to future studies to evaluate these predictions using archival statistical data from sports.

In terms of a coach/performance analyst (with access to performance data) attempting to predict how well an athlete will handle pressure and how they will respond after a high-pressure situation, these findings clearly suggest that using only three performance outcomes in not sufficient, as several important effects are likely to be missed. In terms of a fan or teammate making assessments about whether an athlete is hot or cold, the present findings suggest that it is likely such individuals will misjudge which athletes will choke or be “clutch” under pressure since short performance streaks seem to be unrelated to success under pressure. This could be an important issue as previous research has shown that in-game decisions (e.g., which teammate to pass the ball to in volleyball) can be influenced by streak perceptions based on a small set of performance outcomes (Köppen & Raab, 2012).

Limitations and Future Research

There are some limitations to the current set of experiments that may be addressed in future research. Firstly, the psychometric properties of a single-item scale to measure anxiety may be questioned. It will be important for future research to provide a more complete assessment of the effects of pressure in our conditions using a multiple-item assessment of state anxiety such as the Competitive State Anxiety Inventory-2 (CSAI-2; Martens, Burton, Vealey, Bump, & Smith, 1990).

The pressure manipulation employed in the current study used a combination of monetary incentives and
an evaluative audience, both of which have been commonly used in previous research to successfully increase levels of anxiety (e.g., Bell & Hardy, 2009; Mesagno et al., 2011; Wang et al., 2004). Further support for these manipulations was found, as anxiety levels increased in the pressure phase, with large effect sizes being found for both experiments (Expt. 1: 0.68; Expt. 2: 0.58). We also chose to give participants only one chance to perform under pressure in an attempt to maximize ecological validity. The instruction to imagine a critical game situation was used to emphasize that there was only one opportunity to win the prize money. This one-trial performance under pressure opportunity has, however, previously been shown to be detrimental to reliability (Woodman & Davis, 2008), but the smaller range of possible outcomes in the current study served to reduce the impact of such issues. However, it will be important for future research to investigate performance and attentional effects using other pressure manipulations and larger number of pressure trials.

References


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