JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1992, 25, 657–663 NUMBER 3 (FALL 1992)

BEHAVIORAL MOMENTUM IN COLLEGE BASKETBALL

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Three classes of events were scored from videotapes of 14 college basketball games during the 1989 National Collegiate Athletic Association tournament: *reinforcers* (such as points and favorable turnovers), *adversities* (such as missed shots, unfavorable turnovers, and fouls), and *responses to adversities* (favorable or unfavorable outcomes of the first possession of the ball following an adversity). Within-game and within-team analyses of these data supported three findings. First, a team's favorable response to an adversity generally increased as the rate of reinforcement increased 3 min preceding the adversity. Second, basketball coaches called time-out from play when being outscored by their opponents an average of 2.63 to 1.0. Third, calling time-outs from play appeared to be an effective intervention for reducing an opponent's rate of reinforcement. Rates of reinforcement during the 3 min immediately after a time-out were nearly equal for both teams. Results are discussed within a behavioral momentum framework.

DESCRIPTORS: behavioral momentum, sports behavior analysis, resistance to change, basketball

Sports fans are thoroughly familiar with the notion that behavior has momentum, and sports writers use the term routinely to describe performance in a number of settings. Two common examples occur during a match between two individual tennis players (e.g., the Wheaton–Agassi match, July 5, 1991) and during a football game in which the individual players change every few plays (e.g., the Pittsburgh Steelers, February 4, 1991). One assumption implicit in this concept is that success breeds success. That is, good performance is more likely after a run of winning points than otherwise. Conversely, disruption of winning play by a foul, a time-out, an error, an ill-timed substitution, or the loss of a closely contested point may be inordinately difficult to overcome unless the player or team is "hot."

Sports psychologists also discuss "psychological momentum" as an "added or gained psychological power that changes interpersonal perceptions and influences an individual's mental and physical performance" (Iso-Ahola & Mobily, 1980, p. 391). This psychological momentum is said to be based on early success within a match and to increase the probability of later success (Iso-Ahola & Blanchard, 1986).

The notion that behavior has momentum is, of course, metaphorical. In classical physics, momentum refers to the product of the velocity and mass of a moving body. When the mass of a body is large, its velocity is relatively unaffected by an external force. This metaphor evidently has intuitive appeal, at least in sports, where the "velocity" of winning play may be hard to stop once winning has gained "momentum" (i.e., mass as well as velocity).

The momentum metaphor may also be useful in behavior analysis because it captures two general and separable aspects of behavior: (a) the rate of response (velocity) and (b) the persistence of that

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rate when responding is challenged in some way (mass). A number of studies with human and nonhuman subjects have shown that these aspects of behavior are empirically independent as well as conceptually distinguished (e.g., Mace et al., 1990; Nevin, Tota, Torquato, & Shull, 1990). In particular, it appears that response rate under stable baseline conditions depends primarily on response–reinforcer contingencies. Additionally, the persistence of that behavior appears to be a function of stimulus–reinforcer contingencies. From these findings, a prescription arises: To generate a high level of momentum for a specified class of behavior, arrange a high rate of reinforcement for a high rate of responding in the training situation. Once the behavior is well established, it should persist effectively in the situation correlated with the rich schedule of reinforcement, even when reinforcers are withheld for a time (Nevin, 1988).

The same approach may be used to increase the likelihood of low-probability behavior. For example, working with adults with mental retardation in a group home, Mace et al. (1988) found that subjects were more likely to comply with requests to engage in low-probability behavior if these requests were preceded by frequent reinforcement for compliance with high-probability requests. Interpreted in relation to the momentum metaphor, their findings suggest that reinforcing high-rate instances of compliance endowed the general class of compliance with sufficient momentum to carry over to other requests that normally were resisted. Perhaps because of the situational variability inherent in the group-home setting, this effect on compliance diminished rapidly with time and did not carry over across successive test sessions.

In this correlational study, we ask whether group sports behavior may be functionally similar to compliance. Specifically, will a college basketball team perform better after an adverse event if its scoring rate before the adverse event was high than if its prior scoring rate was low? And will this effect carry over through periods of time-outs? If so, common principles may apply to situations involving teams of varying composition as well as to individuals.

METHOD

Basketball Teams

Seven basketball games televised during the 1989 National Collegiate Athletic Association (NCAA) tournament were unsystematically selected for observation. The sample consisted of the following competitions: Duke versus Georgetown, Duke versus Seton Hall, Illinois versus Louisville, Illinois versus Syracuse, Michigan versus Illinois, Michigan versus Seton Hall, and North Carolina State versus Georgetown.

Target Events and Data Collection

Two trained observers independently viewed videotapes of each of the seven basketball games. Data collection began with the onset of the game clock at the beginning of each half of the game, continued during time-out periods, and was suspended during half-time. Counts of three classes of events were recorded continuously during 10-s intervals for one team at a time (i.e., the target team). *Reinforcers*[1] (obtained by the target team) consisted of 3-point field goals, 2-point field goals, 1-point foul shots, and turnovers favoring the target team (i.e., gaining possession of the ball without the opposition first shooting the ball). *Adversities* (experienced by the target team) were defined as turnovers favoring the opposing team, missed field goals and foul shots, and commissions of (shooting) fouls against the opposing team. *Response to adversities* referred to the outcome of the target team's first possession of the ball following an adversity and included field goals and foul shots, missed field goals and foul shots, commissions of fouls against the opposing team, turnovers favoring the opposing team, and turnovers favoring the target team (i.e., the target team's first possession of the ball follow-

[1] We use the technical term *reinforcer* to refer to the consequences of player actions that obviously maintain the behavior (e.g., a ball passing through the hoop positively reinforces an accurate shot). However, we use the nontechnical term *adversity* to refer to unfavorable events that may or may not function technically as aversive stimuli.

ing an adversity resulting from a turnover). For purposes of data analysis, a team's response to an adversity was classified as either favorable or unfavorable if the outcome of the next possession of the ball resulted in a reinforcer or an adversity, respectively. Events scored as a response to an adversity were also classified and recorded as reinforcers or adversities.

Interobserver agreement was assessed for each event classified as a reinforcer, an adversity, and a response to an adversity. Occurrence agreement, nonoccurrence agreement, and total agreement were calculated on a point-by-point basis by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Mean occurrence agreement was 83.1%, 76.9%, and 81% for reinforcers, adversities, and responses to adversities, respectively. Nonoccurrence agreement and total agreement averaged 98% or higher for all event classifications.

RESULTS AND DISCUSSION

Event data were analyzed to address two hypotheses. The first hypothesis examined whether a team's response to an adversity varied as a positive function of its local reinforcement rate immediately preceding the adversity. To answer this question, the local rate of reinforcement prior to each adversity, inclusive of all periods of time-out, was calculated as follows: The number of events recorded as reinforcers during the 3-min period preceding each adversity was divided by 3 min. (A 3-min interval provided an average of three reinforcers prior to an adversity; reinforcers per minute averaged approximately 1.0 per minute across all games.) These local reinforcement rates were grouped arbitrarily into three discrete classes: 0 or 0.3, 0.67 or 1.0, and ≥ 1.3 reinforcers per minute. Grouping reinforcement rates increased the number of occurrences in each category, allowing for an analysis of more games. However, even with grouping, two teams were dropped from the analysis because there was only one occurrence of reinforcement at the ≥ 1.3 level (one team's result favored the momentum hypothesis; the other did not). In all analyses, each team was compared to itself within the context of a single game and a constant competitor.

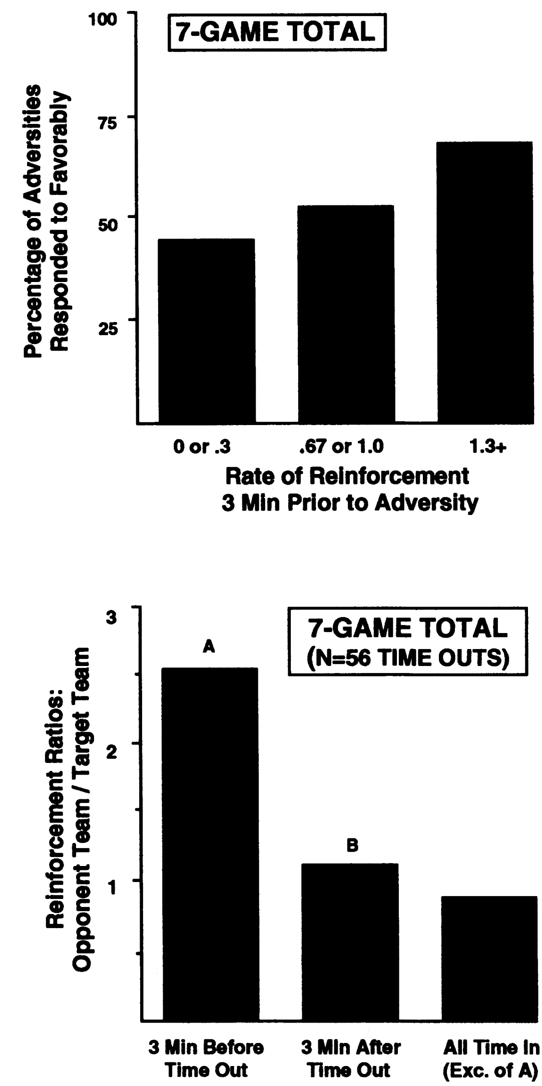

Figure 1. The upper portion shows the percentages of adversities responded to favorably by the target team as a function of the rate of reinforcement 3 min prior to each adversity. The lower portion shows the opponent team's rate of reinforcement in ratio to the target team's rate of reinforcement at three different time periods of the game: 3 min before a time-out, 3 min after a time-out, and all other periods of time-in. The data represent the aggregate of seven basketball games: 12 separate team analyses (upper panel) and 13 separate team analyses (lower panel).

The upper panel of Figure 1 shows the per-

Table 1
Percentage of Adversities Responded to Favorably by Rate of Reinforcement 3 Min Prior to Each Adversity

Game	Rate of reinforcement 3 min prior to adversity		
	0 or 0.3	0.67 or 1.0	1.3+
N.C. State vs.	41%	57%	100%
Georgetown	32%	53%	100%
Seton Hall vs.	20%	57%	80%
Michigan	—	—	—
Illinois vs.	69%	72%	100%
Louisville	39%	50%	67%
Michigan vs.	41%	50%	33%
Illinois	55%	44%	80%
Duke vs.	—	—	—
Georgetown	46%	61%	0%
Duke vs.	46%	32%	25%
Seton Hall	65%	68%	67%
Illinois vs.	46%	50%	No instance
Syracuse	43%	55%	67%
7-game total	44.1%	52.5%	68%

centage of adversities that a team responded to favorably as a function of the team's rate of reinforcement during the 3 min preceding the adversity. These data represent the results of the seven-game total consisting of the average of 12 separate team analyses. When the reinforcers per minute were 0 or 0.3 prior to an adversity, a favorable response to the adversity upon the next possession of the ball was observed an average 44.1% of the time. This value increased to 52.5% and 68% as reinforcers per minute increased from 0.67 or 1.0 to ≥ 1.3, respectively. A chi-square test of the independence of rate of reinforcement and percentage of adversities responded to favorably was calculated at 11.87 ($p < .01$) for the seven-game total.

Table 1 presents the percentage of adversities responded to favorably by rate of reinforcement 3 min prior to each adversity for individual teams. Overall, favorable responses to adversities increased as the rate of reinforcement increased 3 min prior to the adversity for 8 of the 12 (67%) separate team analyses. Of the four analyses not showing this pattern, two showed the reverse pattern, one showed it at the two lower levels but not at the highest level, and one showed comparable percentages across all reinforcement rates.

The second hypothesis concerned whether calling a time-out from play is an effective intervention for reducing the opponent's rate of reinforcement and, hence, its behavioral momentum. The local reinforcement rate of the opponent team was placed in ratio to that of the target team to reflect the relative rate of reinforcement between the two teams at various points in the basketball game. Reinforcement ratios were calculated for (a) the 3-min period preceding each time-out called by the target team, (b) the 3-min period following the end of each time-out called by the target team, and (c) all time-in periods exclusive of (a).

The lower panel of Figure 1 shows that the timing of a team's call for a time-out from play correlated positively with that team's rate of reinforcement relative to its opponent. The figure illustrates this relationship for the average of all seven games, or 13 separate team analyses (one team analysis could not be conducted because the denominator of the ratio was zero). A comparison of the rate of reinforcement ratio at 3 min before each time-out with the ratio for all other periods of time-in indicates that time-outs were called when the opponent's rate of reinforcement was, on average, 2.63 times greater than that of the target team. By contrast, the rate of reinforcement ratio was 0.84 for all other time-in periods.

We can speculate that time-out from play may be an effective intervention for decreasing the opponent's momentum in the game. For the seven-game average, the rate of reinforcement ratio dropped from 2.63 during the 3-min period before time-out to 1.11 during the same interval following time-out periods. That is, by interrupting play and suspending the opportunity to obtain reinforcers, target teams reduced their opponents' relative rate of reinforcement to an average of 44% of the pre-time-out level. Table 2 shows that this pattern was evident for 12 of the 13 separate team analyses. (The one exception showed the reverse pattern.)

The results reported here appear to disagree with the findings of Gilovich, Valone, and Tversky

(1985). They analyzed the shooting records of individual basketball players and found the probability of hitting a shot to be essentially independent of preceding runs of up to three hits or misses. They concluded that the widely accepted notion of the "hot hand" in basketball is the result of a misperception of the probability of short sequences of hits in a random string of events. However, our data are based on team rather than individual performance, employ a different sampling period (3 min as opposed to successive shots), and include favorable turnovers as well as points scored in estimating the reinforcer rate for the preceding period. Moreover, our interest centers on performance after the challenge of an adversity; for Gilovich et al. (1985), this would be the probability of hitting given two prior hits and then a miss, compared with the probability of hitting after only one or no hits before a miss. They do not report these comparisons. Therefore, there is no necessary contradiction with their data.

Table 2
Reinforcement Ratios: Opponent Team/Target Team

	Reinforcement ratios		
Game	A 3 min before time-out	B 3 min after time-out	C All time-in
N.C. State vs.	2.50	1.00	0.85
Georgetown	2.50	1.50	0.48
Seton Hall vs.	1.10	2.03	0.85
Michigan	2.80	2.48	0.95
Illinois vs.	1.50	0.67	0.80
Louisville	1.72	1.11	1.04
Michigan vs.	5.88	0.78	0.76
Illinois	1.77	0.49	0.71
Duke vs.	—	—	—
Georgetown	1.00	0.67	1.04
Duke vs.	3.60	0.78	1.00
Seton Hall	1.79	0.80	0.74
Illinois vs.	6.80	1.68	0.91
Syracuse	1.25	0.44	0.89
13-team total	2.63	1.11	0.85

Beyond the "hot hand" issue, our data have several implications. The first has to do with the sport of basketball in particular, and perhaps with sports in general. Although the data reported here are descriptive rather than experimental, it appears that calling time-out from play is an effective intervention for interrupting an opponent's scoring streak or their behavioral momentum. Basketball coaches seem to know this intuitively; however, carefully timing each time-out from play may improve its effectiveness. Our results suggest that calling a time-out early in an opponent's scoring streak may avoid the opponent's accumulation of several "unanswered" points. For example, in the Illinois versus Louisville game, Illinois called time-outs when being outscored 1.5 to 1.0. By contrast, Michigan waited to call time-out from play with Illinois when being outscored 5.9 to 1.0. In both cases, time-out dramatically reduced the opponent's scoring; however, we might speculate that it would have been in Michigan's interest to interrupt play earlier in Illinois' scoring streak to prevent their opponent's accumulation of a substantial number of points. A second suggestion we have is for coaching personnel to analyze reinforcement rates for individual players on a minute-by-minute basis during actual play. These data may permit coaches to make data-based decisions about player substitutions and may permit the point guard to pass the ball to players whose local rate of reinforcement is relatively high.

The results reported here may also have some significance for behavior analysis in general. Although they are observational data on the sports performance of teams, the results are consistent with the experimental findings of Mace et al. (1988) for compliance in individual group-home residents in two ways. First, the probability that a team would respond favorably to an adversity was greater if the adversity was preceded by a high rate of reinforcement than if it was not. This is functionally similar to the finding that the probability of compliance with a request to engage in low-probability behavior was greater if the request was preceded by a high rate of reinforcement for compliance than if it was not. Second, the effectiveness of a team's performance relative to its opponent was sharply reduced following a time-out called by the opponent. This is functionally similar to the finding that the probability of compliance with a request to engage in low-probability behavior was lower if some time had elapsed since previous reinforcement for compliance (see Experiment 3 in Mace et al., 1988).

These two similarities suggest that it may be appropriate to view a sports team as an aggregate organism whose behavior is functionally similar to that of an individual subject. Although counter-intuitive to a behavior-analytic perspective, the concept does have precedent in the experimental literature. This view is consistent with Baum's (1974) finding that the key pecking of a flock of wild pigeons, whose membership varied in an unknown way, conformed to the matching law for concurrent operants, which is well established for individual subjects (for review, see de Villiers, 1977). Similarly, Graft, Lea, and Whitworth (1977) obtained a good approximation to matching by the aggregate lever pressing of a group of 5 rats, and Grott and Neuringer (1974) observed that schedule performance by a group of rats housed together was comparable to standard schedule performance of individuals rats. Finally, Morgan, Fitch, Holman, and Lea (1976) obtained stimulus control by a visual concept ("A" vs. "2" in various typefaces) in a varying group of free-ranging pigeons that was comparable to conceptual stimulus control of individual pigeons in controlled experiments.

The analysis of social behavior would be much enhanced if aggregate group behavior conformed to the same principles as that of individual organisms. It is important to determine whether such analyses could be applied to all social groups or only to those experiencing intensive training together that demanded mutual interaction and support (as with sports teams or combat units).

An alternative view might treat each individual player's behavior as affected by the reinforcers obtained by other players. This could arise in several ways. Perhaps most obviously, a well-timed and accurate pass may be reinforced if it permits another player to score, thus strengthening the general class of effective play. Less directly, effective play may be facilitated by reinforcers obtained by other players serving as models, and supportive emotional responses may be generated by vicarious conditioning. These alternatives gain in plausibility if it is generally true that reinforcers experienced in the situation tend to increase resistance to disruption regardless of whether they are contingent on the subject's target response (e.g., Mace et al., 1990; Nevin et al., 1990).

We want to emphasize that the conclusions offered here need to be tempered by the strength of the evidence. The data are correlational, not experimental. Thus, the relationships between rate of reinforcement and team performance suggest functional relationships rather than demonstrate them. Our hope is that this correlational study will stimulate further research with team sports on this topic and others relevant to behavior analysis. In addition, we see heuristic value in the consistency of our correlational data with basic behavioral processes discovered using experimental methods with animals and humans.

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Received August 31, 1991
Initial editorial decision October 23, 1991
Revision received February 6, 1992
Final acceptance May 22, 1992
Action Editor, David Wacker